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Canadian Council of Ministers of the Environment
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PROCEEDINGS

DIOXIN WORKSHOP
QUEBEC CITY

May 7 and 8, 1987

CCME-TS/TRE-025

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS

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DRAFT FOR APPROVAL

91-01557/

Canadian Council of Ministers of the Environment 1990
ISBN 0-919074-46-4

Canadian Council of Resource and Environment Ministers

Dioxin Workshop

EXECUTIVE SUMMARY

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CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS
DIOXIN WORKSHOP

Executive Summary

Recommendation: That a Dioxin Sub-Committee of the Toxic Substances Advisory Committee be formed to develop an action plan consisting of the following elements: a communications strategy; assistance to provinces that require analytical and assessment expertise; the development of consistent control standards that incorporate life cycle and multi-media approaches; and a targetted scientific research program.

Introduction

During May 7-8, the Canadian Council of Resource and Environment Ministers (CCREM) sponsored a Dioxin Workshop in Quebec City. Sixty-one participants represented the senior scientific and policy-making staff of the federal government's and eight provincial governments' ministers concerned with environmental and health issues.

Workshop Objectives

The workshop had four objectives:

1. to facilitate sharing of the most recent information on dioxins;
2. to define common goals and priorities for government action at the national, regional and provincial levels;
3. to prepare an action plan that is acceptable to all parties; and
4. to determine a basis for a communications strategy on dioxins.

Workshop Structure

The workshop opened with a plenary session consisting of short presentations that reviewed the dioxin problem from the following eight perspectives: an historical overview; the need for reliable analytical data; current knowledge about dioxin levels in humans and the ambient environment; current combustion sources; dioxin hazards in pesticides; industrial and municipal effluents as dioxin sources; the toxicological effects of exposure to dioxins and the establishment of environmental standards.

Following these presentations, the participants separated into four working groups: Control Technology, Regional Issues, Public Exposure and Standards.

Each working group was asked to discuss priorities for action in five major categories of issues: communications, regional, regulatory, scientific and economic. These discussions took place throughout the afternoon of the first day and the morning of the second. On the afternoon of May 8, the participants again met in plenary session to summarize their conclusions.

Workshop Achievements

The workshop was highly successful, with participants welcoming the opportunity to share the most recent information available about dioxins in Canada. The working group format enabled them to identify numerous goals and priorities for action, to consider the steps that must be taken prior to initiating a comprehensive action plan for future dioxin management, and to determine the basis for a communications strategy that would contribute to public understanding of dioxin-related issues. The discussions also led to the conclusion that, with so many issues requiring further examination, it would be premature to recommend an action plan per se prior to the establishment of a Dioxin Sub-Committee.

Complete summaries of the conclusions reached by the working groups on Control Technology, Regional Issues, Public Exposure and Standards appear in Sections II and III of this report. Those emerging as conclusions identified in common by all four groups appear in this Executive Summary.

Workshop Conclusions

Establishment of a Dioxins Sub-Committee Reporting to TSAC

In reviewing the many priorities identified by the dioxin workshop working groups, it became apparent that there was a need for overall coordination that could be achieved most efficiently by a focussed sub-committee. Such a committee could ensure an appropriately timed and coordinated basis for dioxin management in Canada and could initiate action on those priorities identified by all four working groups, namely:

1. Communications priorities

   Each working group recognized a need for a communications strategy consisting of numerous initiatives such as:

   - "good news stories" as part of regular state-of-the-environment reports;
   - release of CCREM's current relevant fact sheets on dioxins;
   - development of additional fact sheets for state-of-the-environment reporting; and
   - development of a national technical resource information network that would coordinate regional information for consistency and provide up-to-the-minute scientific information for professionals in government who deal with dioxin-related matters.

2. Regional Priorities

   Workshop participants agreed with the Regional Issues working group that many provinces did not have access to sufficient analytical and technical expertise to assess the severity of dioxin-related problems. The Workshop felt that a Dioxins Subcommittee could address some of the related issues by:

- helping provinces to assess whether they have a problem with dioxins;
- identifying deficiencies in analytical procedures and developing options for identifying them; and
- working towards quality control and efficient, low-cost detection methods.

3. Regulatory Priorities

The participants agreed on a need for consistent standards based on multi-media and life-cycle approaches to controls together with prudent application of interim measures such as the current 2,4-D and PCB Action Plans and the National Codes for Wood Protection and Preservation. A Dioxins Sub-Committee could begin working towards:

- the adoption of national multi-media standards for the ambient environment;
- a Canadian scheme for single toxic equivalency factors (TEFs);
- emission standards for incinerators; and
- inclusion of dioxins under the Transportation of Dangerous Goods Act.

4. Scientific Priorities

The workshop participants agreed that while they could identify many gaps in scientific knowledge, it is unlikely that Canada (or other countries) will ever find sufficient resources to undertake the full range of these studies. Consequently, they recommended that the Sub-Committee develop an action plan that would include costs and time frame to address:

- improved analytical ability and capability;

- data gaps that affect ability to assess exposure risks; and
- environmental trends analysis.

5. Economic Costs and Benefits

The workshop did not address economic costs and benefits in detail. However, the participants recognized that the economic costs for acting upon the priorities they identified would be very high. They concluded that carefully targetted research could minimize some of these costs and that CCREM could provide a useful forum for coordinating these efforts.

ACKNOWLEDGEMENTS

The Canadian Council of Resource and Environment Ministers wishes to express its thanks to all those whose generous contribution of their time and talents made the workshop possible.

Particular appreciation is extended to

- the Organizing Committee:

Gaston Paulin (Chairman)
Environment Canada

Martin Boddington
Environment Canada

Beverley Thorpe
Ontario Ministry of the Environment

John Ward
B.C. Ministry of the Environment

Leslie Whitby
Environment Canada

- the Speakers:

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Ontario Ministry of the Environment

Martin Boddington
Environment Canada

Murray Brooksbank
Environment Canada

Jean-Pierre Gauthier
Ministere de l'Environnement du Quebec

Andrew Gilman
Health and Welfare Canada

David Hay
Environment Canada

Laurence McClelland
Agriculture Canada

Ross Norstrom
Environment Canada

Helle Tosine
Ontario Ministry of the Environment

- the Session Chairpersons:

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Environment Canada

Beverley Thorpe
Ontario Ministry of the Environment

- the Workshop Facilitators and Rapporteurs:

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Environment Canada

Raynald Brulotte
Ministere de l'Environnement du Quebec

Walter Giles
Ontario Ministry of the Environment

Andrew Gilman
Health and Welfare Canada

Simon Godin
New Brunswick Department of Municipal
  Affairs and Environment

Ronald Gotts
Ontario Ministry of the Environment

Victor Shantora
Environment Canada

John Ward
B.C. Ministry of Environment & Parks

Ivy Wile
Ontario Ministry of the Environment

A full list of workshop participants appears in Appendix I.

INTRODUCTION

On May 7 and 8, 1987, a Dioxin Workshop was held in Quebec City under the auspices of the Toxic Substances Advisory Committee of the Canadian Council of Resources and Environment Ministers. The Council has for 25 years acted as a unique intergovernmental forum for discussion of environmental policy issues that are of interest to all participants - the federal, provincial and territorial governments.

The Toxic Substances Advisory Committee was established in 1984 to help the Council address the problems of toxic substance management. As contamination by dioxins and furans is a major component of this issue, an ad hoc working group of the Advisory Committee organized the workshop to achieve four main objectives:

- to facilitate sharing between governments of the most recent information on dioxins;
- to define common goals and priorities for government action at the national, regional and provincial levels;
- to prepare an action plan on dioxins that is acceptable to all member governments;
- to determine the basis for a national communication strategy on dioxins.

These proceedings reflect the flow of events at the workshop. Appendix I includes the extended abstracts of all the formal papers prepared in advance and distributed to participants ahead of the workshop.

The workshop opened with a plenary session (Section 1) consisting of short technical presentations that reviewed the dioxin problem from eight different perspectives:

- an historical overview of the key international incidents that led to scientific and public awareness of the dioxin issue;

- the need for reliable analytical data upon which to base risk asssessment, and the technical constraints affecting production of such data;
- current knowledge of the dioxin levels in humans, the food supply, wildlife and the ambient environment;
- the various combustion sources of dioxin and current efforts to minimize dioxin emissions from combustion;
- federal efforts to determine and then reduce the hazards of dioxin in pesticides;
- industrial and municipal effluents and waste as dioxin sources;
- the known toxicological effects of acute and long-term exposure to dioxins;
- the multi-media approach to establishing environmental standards.

Following the first plenary session, the participants separated into four working groups on Standards, Control Technology, Public Exposure, and Regional Issues. Under the guidance of facilitators and resource staff, each group were asked to bring forward conclusions and priorities for action in the areas of communications, regional issues, regulations, science and economics.

The final conclusions of each working group, were presented at the second plenary session (Section 2).

The proceedings conclude, as did the workshop, with a summary statement presented by the session chairperson, Beverley Thorpe.

SECTION 1

FIRST PLENARY SESSION - SPEAKERS' PRESENTATIONS

KEYNOTE ADDRESS

Jean-Pierre Gauthier
Assistant Deputy Minister
Quebec Ministry of the Environment

Madam President, ladies and gentlemen, welcome to Quebec for this important meeting on dioxins and furans.

We now have a better understanding of these toxic substances which are found throughout the environment. We also know that even at negligible and apparently harmless dose levels, these substances deserve serious evaluation. The problem is, of course, that once produced, they are extremely stable and gradually accumulate in the environment.

As you have been told, the present gathering is being held under the responsibility of the Toxic Substances Advisory Committee of the Canadian Council of Resource and Environment Ministers. The Council came into existence a little over 25 years ago as a unique intergovernmental forum in which all ten provinces and the federal government sit at the Council table as equals. The territorial governments also attend. The presidency rotates among the member governments, and for 1986-87 the presidency is held by Quebec.

The Council itself consists of Ministers, primarily holding environment portfolios. The focus is on policy issues that have been selected for discussion at each annual meeting. The emphasis is on consultation and debate, in order to improve understanding of key issues and the options that exist.

The Toxic Substances Advisory Committee came into existence after the 1984 Annual Council Meeting, where the crucial issue of toxic substances management and the growing concern among Canadians about these substances were major subjects of discussion.

The Advisory Committee, even relatively young, has helped produce results in many areas: a comprehensive approach to PCBs, planned activities in hazardous waste management, a review of pesticide problems and the search for public acceptance, dissemination of information and knowledge about the effects of toxic substances.

The Toxic Substances Advisory Committee has established working groups for specific tasks. Among these is an "ad hoc" working group to review and analyze the issue of dioxins and furans in Canada and to identify and propose a list of prioritized actions to be undertaken.

The "ad hoc" working group was formed in the spring of 1986 with a chairman from Quebec and members from Ontario, British Columbia and the federal government. As well as producing a number of reports on dioxins and furans, it planned and prepared the present workshop, which results from the following background situation:

The extent of Canadian world leadership, expertise and scientific effort on the dioxin issue is not well-known by the Canadian population. There is a need for Canada's federal and provincial governments to present consistent and comprehensive information to the public and to tell Canadians of our achievements in this area.

There is a need to coordinate all the knowledge and information held by the responsible government bodies in Canada. A recent review of ongoing work on dioxins in Canada has estimated that the current annual level of expenditure is $9 million.

I would like to add a few words on our goals for this workshop.

We hope that this workshop will enable you to determine the current level of knowledge on dioxins and furans, and to identify the sectors or regions where hazardous levels of these toxic substances exist in air, water, soil or food supplies. With this information, you should be able to get an overview of the problem and identify priorities for action in the technical and environmental management fields.

I believe that the workshop format is especially well suited to reach the objectives that have been set. This morning, you will hear up-to-date accounts from experts in the various fields and sectors where dioxins and furans create a potential problem and challenge: global and Canadian perspectives, analysis problems, levels found in many environmental media, sources, effects on human health, and regulatory approaches. This afternoon and tomorrow morning, four separate workshops will be held where you will be required to use your knowledge to suggest future directions in the areas of Standards, Control Technology, Public Exposure and Regional Issues. You will also be invited to indicate what actions must be completed, continued or initiated, together with their order of priority. The results of your deliberations will be presented at the last plenary session tomorrow afternoon where, I hope, a general consensus can be achieved.

In the name of the Toxic Substances Advisory Committee, may I close by thanking you sincerely for coming here to offer us the benefit of your individual knowledge, so that the problem of dioxins and furans can be controlled and managed with the best possible methods. The joint efforts of all our governments will produce, I am sure, important results to add to these already achieved by the Committee.

I would like to thank all of you for your participation and wish you a pleasant stay in Quebec.

DIOXINS - AN OVERVIEW

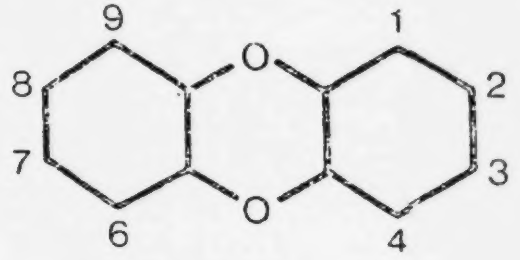
Dr. Martin J. Boddington
Chief, Biotechnology Centre, Conservation and Protection
Environment Canada

It's my job today to take you back over the last 40 years and give you a flavour of what the dioxin issue is all about.

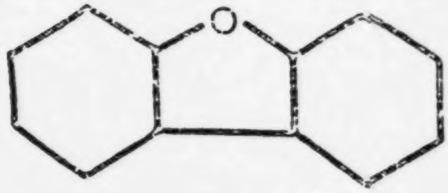
To start off, let's talk about what dioxin is - a chemist's eye view of dioxins. There are two benzene rings - dibenzo, connected by two oxygens - dioxin, in the para position - dibenzo-para-dioxin (Figure 1).

FIGURE 1

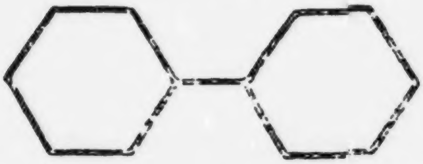
Dibenzo - P - dioxin

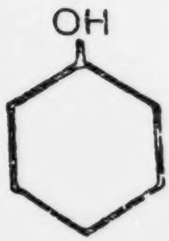


Dibenzofuran



PCB





Phenol

Chlorine can be added to any one of the numbered positions. There can be one chlorine, mono, up to eight chlorines, octa-dioxin, and you can have any combination between di - 2, tri - 3, tetra - 4, penta - 5, hexa - 6, hepta - 7 chlorines. In fact you could add chlorine to the basic structure in 75 different ways and so you have 75 different dioxins. The most common one is when you have chlorine at 2,3,7, and 8 positions, giving 2,3,7,8 tetrachlorodibenzo-para-dioxin or TCDD.

Closely related to the dioxins are dibenzofurans. Again dibenzo, i.e., two benzene rings, connected this time by only one oxygen; and that's the furan structure.

We can move along and take the oxygen away and just have a single bridge between two benzene rings; this is called biphenyl, and if they are chlorinated you have polychlorinated biphenyl, PCBs.

A single benzene ring which is hydrated with an OH is the basic phenol structure. This can be chlorinated in different positions. You'll be hearing about trichlorophenols, pentachlorophenols, and so on.

What made dioxin such an issue was its toxicity (Figure 2). Let's discuss dioxin relative to the toxicity of other well-known poisons, like botulism, tetanus and diphtheria. These are all much more toxic: ten million, a million, a thousand times more toxic than 2,3,7,8-TCDD. But curare, strychnine and cyanide, also well-known poisons, are much less poisonous than dioxin, up to a hundred thousand times less toxic than dioxin. So you're dealing with a fairly toxic molecule; this is why scientists were concerned right from the discovery of dioxin back in 1968.

FIGURE 2

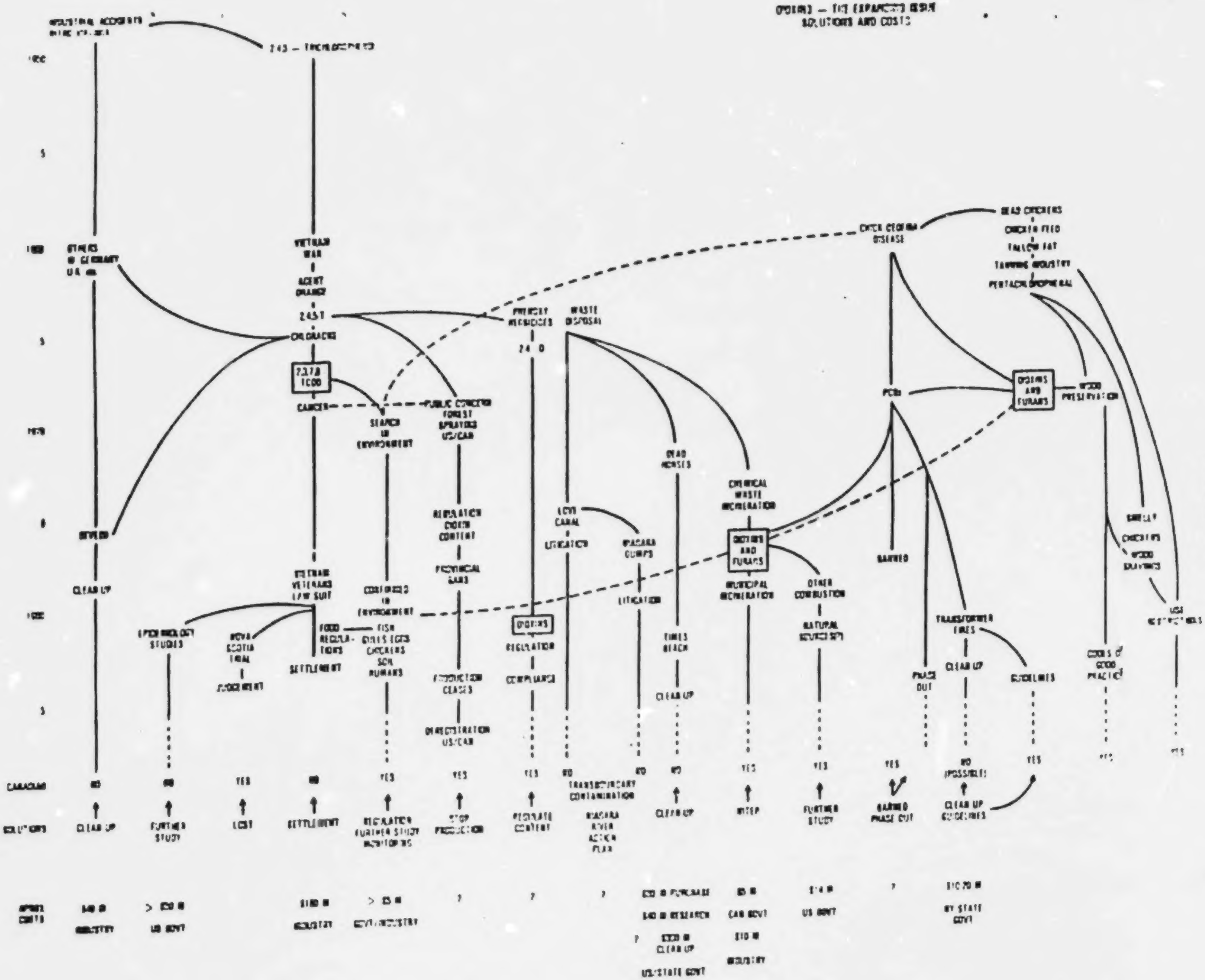
RELATIVE TOXICITY OF SELECTED ~~POISION~~ Poison
(after Esposito et al, 1980)

TOXIN	RELATIVE LETHALITY
Botulinum	10,000,000
Tetanus	1,000,000
Diptheria	1,000
2,3,7,8-TCDD	1
Curare	1/100
Strychnine	1/1000
Cyanide	1/100,000

How do we go through some of the issues that have led us to where we are today? There's no really good single starting point, so I've chosen several different starting points to take you through the issues (Figure 3).

One group of compounds that I didn't mention were phenoxy herbicides. These are a series of pesticides that were discovered in 1942; their importance was because they mimicked plant hormones, and if you spray enough on a plant, the plant will grow so fast it kills itself. This was very good for weed control. But they were used in Vietnam as a defoliant so that the trees would not provide cover for the enemy. The compound used was called Agent Orange, a mixture of two different phenoxy herbicides: 2,4,5-T (trichlorophenoxy-acetic acid) and 2,4-D. When Dow Chemical were routinely testing for the safety of the compound 2,4,5-T, this mixture was found to produce a disease called chloracne in rabbits. Chloracne is like, in its minor form, a lot of little blackheads on either the face or the upper body; in its severe form it can form big pustules or boils. So, why did 2,4,5-T form chloracne? The answer was eventually discovered in 1968 to be 2,3,7,8-TCDD.

FIGURE 3



DIOXINS — THE EXPANDED ISSUE
SOLUTIONS AND COSTS

1950
5
1960
5
1970
5
1980
5
CANADIAN
SOLUTIONS
APPROX. COSTS
INDUSTRIAL ACCIDENTS
NITRO VA. 1949
245 — TRICHLOROPHENOL
OTHERS
IN GERMANY
U.K. etc.
VIETNAM
WAR
AGENT
ORANGE
245T
CHLORACNE
2378
TCDD
CANCER
SEARCH
IN
ENVIRONMENT
PUBLIC CONCERN
FOREST
SPRAYING
US/CAN
PHENOXY
HERBICIDES
24 D
WASTE
DISPOSAL
SEVESO
CLEAR UP
VIETNAM
VETERANS
LAW SUIT
EPIDEMIOLOGY
STUDIES
NOVA
SCOTIA
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JUDGEMENT
FOOD
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CONFIRMED
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FISH
GULLS EGGS
CHICKENS
SOIL
HUMANS
REGULATION
EXCESS
CONTENT
PROVINCIAL
BANS
PRODUCTION
CEASES
DEREGISTRATION
US/CAN
DIOXINS
REGULATION
COMPLIANCE
LOVE
CANAL
LITIGATION
NIAGARA
DUMPS
LITIGATION
DEAD
HORSES
TIMES
BEACH
CLEAR UP
CHEMICAL
WASTE
INCINERATION
DIOXINS
AND
FURANS
MUNICIPAL
INCINERATION
OTHER
COMBUSTION
NATURAL
SOURCES(?)
CHICK EDEMA
DISEASE
PCBs
BANNED
PHASE
OUT
TRANSFORMER
FIRES
CLEAR UP
GUIDELINES
DEAD CHICKENS
CHICKEN FEED
TALLOW FAT
TANNING INDUSTRY
PENTACHLOROPHENOL
DIOXINS
AND
FURANS
WOOD
PRESERVATION
CODES OF
GOOD
PRACTICE
SHELLY
CHICKENS
WOOD
SHAVINGS
USA
RESTRICTIONS
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NO
YES
YES
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TRANSBOUNDARY
CONTAMINATION
NO
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(POSSIBLE)
YES
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YES
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STUDY
LOST
SETTLEMENT
REGULATION
FURTHER STUDY
MONITORING
STOP
PRODUCTION
REGULATE
CONTENT
NIAGARA
RIVER
ACTION
PLAN
CLEAR UP
MTEP
FURTHER
STUDY
BANNED
PHASE OUT
CLEAR UP
GUIDELINES
$40 M
INDUSTRY
> $50 M
US GOVT
$180 M
INDUSTRY
> $5 M
GOVT/INDUSTRY
?
?
?
$30 M PURCHASE
$40 M RESEARCH
?
$300 M
CLEAR UP
US/STATE GOVT
$5 M
CAN GOVT
$10 M
INDUSTRY
$14 M
US GOVT
?
$10-20 M
BY STATE
GOVT

Now, the issue stayed around for a long time in the 1970s; a lot of science was done and a lot of concern in the general public was initiated during that period. But the relationship to the Vietnam war carried on right into the 1980s when the Vietnam veterans, afraid of the exposure they had to 2,4,5-T in the Vietnam war, eventually took eight chemical companies to court. About 1985, this was settled out of court for $180 million. One of the spinoffs from this particular lawsuit in the United States was the Nova Scotia trial of Judge Nun, where the plaintiffs were environmental groups, again trying to stop a forest company from using 2,4,5-T for brush control. This failed, from the viewpoint of the plaintiff. Now the Sprayers of Dioxin Association has taken Dow Chemical to court in Michigan this year. So this is the legal aspect of dioxins.

The phenoxys in their relationship to Agent Orange and 2,4,5-T were not only through the Vietnam war but through their domestic use as well. One of the real political issues was about forest spraying because 2,4,5-T and 2,4-D were used for brush control in forests. The particular incident that is very pivotal occurred when a group of Oregon housewives felt that in their area there were more miscarriages occurring than was natural, so they documented the miscarriages and got a lot of publicity from these findings. Under scientific analysis their findings didn't hold up, but by that time the damage to the cause of forest spraying had already been made and regulation followed quickly afterward in terms of the amount of 2,3,7,8-TCDD permitted in the phenoxy herbicides.

But regulation wasn't enough. 2,4,5-T was already endangered. A number of provinces started banning 2,4,5-T use: British Columbia and Saskatchewan were two of them. In Ontario Bill Davis said he wouldn't lose an election over a chemical. Finally production ceased. The last company to be producing this I think are in New Zealand. Canada decided not to re-register 2,4,5-T in 1985 and it effectively became illegal for use on the first of January, 1986.

This relationship between 2,4,5-T and 2,4-D, which as I said was the mixture that made up Agent Orange, didn't really surface until the 1980s when again Agriculture Canada identified not 2,3,7,8-TCDD but other dioxins in 2,4-D. The regulation was passed almost immediately and we now have good compliance to what I think is the only regulation on 2,4-D in the world.

The starting products for phenoxy herbicides were trichlorophenols, which were to be associated with a lot of problems. 2,4,5-trichlorophenol was sold as a mouthwash, and in Britain it was called TCP. It was responsible for a lot of industrial accidents. There's an unstable part in the reaction, which if it isn't controlled and all the right valves don't work, the plant blows up. The first plant to blow up was in Nitro, Virginia in 1947, and one of the fathers of dioxins, Susskind, is still following an epidemiological study of people exposed during that accident.

There were a number of other accidents during the 1950s, 1960s and 1970s -- in the United Kingdom, Germany, Holland -- about 15 altogether. The most famous was in 1977 at Seveso, near Milan, Italy, where a wide area around the plant was contaminated. A number of animals died and a lot were slaughtered. A Papal dispensation was given for abortions for pregnant women living in the area and, in fact, the Pope came back a bit later and blessed the land and said it was all safe. Hoffman-LaRoche spent $70 million to clean up the area. It resulted in a very large facility, something like the Big O in Montreal, full of contaminated soil.

At Seveso and at many of the other accidents, chloracne was the only human effect noted. Chloracne is the tie-in between what scientists found in animals and what has been found in humans.

One of the other products of trichlorophenol that's been associated with these accidents is hexachlorophene. Hexachlorophene, again, if anybody can remember that far back, was the red stripe in Signal toothpaste. It's a disinfectant. It was used predominantly in maternity wards. After some babies died as a result of exposure, it was severely limited in the ways it was used. It's still available in some soaps that we use today, particularly those for people with allergies.

The other problem with trichlorophenol was wastes, because the wastes contained 2,3,7,8-TCDD. There were several incidents associated with the dioxin wastes from trichlorophenols, the most famous being the Love Canal. This is often forgotten today as being a dioxin incident. One of the major scientific outcomes of the Love Canal was in fact guidelines on the way that mutagenicity tests were carried out. A number of houses were evacuated on the basis of an environmental group doing studies on mutagenicity. The mutagenicity concern, when scientists obtained the data, didn't stand up. As a result, a series of guidelines came out as to how to do these studies properly so that people would know whether they were in danger or not.

The Love Canal, in terms of clean-up, went to litigation, and there are other Niagara dumps - Hyde Park, S Street, 102nd Street - which are also in litigation. The continuing media coverage led to an action plan, signed this year between the four major parties: the United States, New York, Canada and Ontario.

The other waste problem was known in scientific circles for many years as the "horse arena" incident. This is because wastes from a hexachlorophene-producing plant had been mixed with oils, including PCB oils, and used by a waste-sprayer to keep down dust on roads. This is a common practice. It's done in your own communities if you have dirt roads. The waste was also sprayed in horse arenas to keep the dust down and a number of the horses got sick; some died; children got sick. It took a long time to determine why these horses had died and what they had died from. The issue sort of rumbled around Missouri and Kansas for a long time; in fact, through to about late 1983 and early 1984. Then a flood in an area called Times Beach occurred and the whole community became contaminated and was evacuated. The clean-up is still going on there. The cost of buying the place out was about $30 million; the cost of the scientific effort about $40 million, and the clean-up will probably cost in the region of $300 million.

The chlorophenols and many of the chlorinated products are a result of chemical companies trying to use up chlorine. They've taken salt and split off sodium, The sodium is used to make alkali and, in fact, the chloralkali inspectors were one of the earliest forms of environmental protection in England and I think in North America. The end result is a lot of chlorine.

Chemical companies were often situated on a salt mine, and for many years they used the mines to get rid of their wastes. This came to light during the St. Clair River incident. Dow (Sarnia) used its salt mines to dispose of its waste. It had been a concern at Dow in Michigan, where they put in a chemical incinerator in the early 1970s so that they wouldn't be burying their waste in the salt mine. Without trying to put too much flavour to the story, Dow found that the background level in their factory was much higher than they thought it should be and they traced it back to combustion. They formulated a hypothesis -- the Dow hypothesis -- the "trace chemistries of fire" theory that was published in 1976. This created enormous scientific controversy at the time. Nobody believed it. Everybody said it was a "smokescreen" that Dow was putting out to cover up its chemical problems.

By 1980, municipal incineration had been recognized as a major source of dioxins in the environment. It led to the formation in Canada of the National Incinerator Testing Evaluation Program (NITEP), which is probably one of the leading programs in the world on how to deal with municipal incinerators. It will result next year in an action plan on how to best control the problem.

The concept of combustion led to an awareness that other things, when burnt, produce dioxins; PCBs for instance. PCBs do not themselves produce dioxins; they produce furans. But when PCBs are in mixtures with things like mineral oils or chlorobenzenes, which are replacements for PCBs, they do produce dioxins. The incineration of PCBs, both in mobile incinerators and in transformers in buildings, has become a problem in certain areas. There was a big fire in San Francisco and there was another one in Binghampton, New York, where a whole building was evacuated: I believe it still has not been reoccupied.

Not only was municipal incineration a source, but there were many many other incineration sources, such as hospitals. In the next year, you're going to see some work come out of Germany on diesel engines, which they're very concerned about. Steel mills: again data will be coming out soon from Sweden. Forest fires: there's always been conjecture that this is a possible source. Nobody's ever done any tests on it but we know from historical background levels, back before industrialization, that probably the contribution of forest fires is not as great as industrialization and the chemical industry.

For those interested, cigarettes produce dioxins, but then they also produce a lot of other things; it's probably not worth considering them separately from anything else.

The other major chemical line is pentachlorophenol. The inclusion of pentachlorophenol in the dioxin issue goes back to a flock of dead chickens in the United States. They were found to have died because of the food they ate. Tallow fat, which is a byproduct of the tanning industry, had been used to enrich the feed. The tanning industry used pentachlorophenol. In 1968, about the same time as 2,3,7,8-TCDD was identified, the dioxin and furan content of pentachlorophenol was blamed for the death of these chickens that had occurred ten years earlier; that's the amount of time it took to determine the cause. The birds died of chick oedema disease, where tissues swell from excess water. Chick oedema disease was also known to be caused by PCBs.

Pentachlorophenol is used primarily for wood preservation. Wood preservation has never really hit the papers until recently, and fortunately we've been able to develop Codes of Good Practice in Canada for the industry before there was any particular outcry.

Pentachlorophenol also led to another incident in Quebec, which I call "smelly chickens"; they weren't dead this time but they smelled. This occurred because pentachlorophenol naturally converts into another compound called a chloranisol, which is very smelly. A fast food company, when it was delivered several smelly chickens, investigated why they smelt. It came back to pentachlorophenol, but this time from wood shavings, which are a byproduct from the wood preservation industry; the shavings are sold to farmers for bedding for chickens and pigs.

This resulted in a number of use restrictions, about 1981, by Agriculture Canada. However, there may still be some concern that there may be a problem associated with their use.

Although those are all the different leads and the different investigations that have been going on, the main issue has been what has been found in the environment. Around 1970 it was realized that PCBs, dioxins and furans caused chloracne and chick oedema disease, and scientists started searching for these compounds in the environment. They didn't have the methods, and it took ten years to develop them. Even in 1970 they knew that they had to detect parts per trillion in order to say that these compounds were at significant levels.

During the 1970s there were many false positives, which caused a lot of concern in the media. Dioxin became a household word during that time. When analytical methods became available by the late 1970s, dioxins were found in such things as herring gull eggs, chickens, fish, pigs, humans, drinking water, food and breast milk. However, the number of potential sources had become so great that it was impossible to know which source - the phenoxys, chlorophenols, PCBs, combustion, or more recently, pulp and paper - contributed most to environmental contamination.

Figure 3 summarizes the dioxin problem. About 20 issues, costing many, many millions of dollars; it's now considered that we're in our second billion, and this includes worldwide research, settlements, product loss and basic bureaucratic time like today.

Dioxin has contributed much to the development of environmental science and has made significant contributions in many specific areas, like analytical chemistry, risk analysis and epidemiology. It has turned science over, but it has also turned law over and it has turned management over. We know that we can contain some situations by good communication but mainly by clear and coordinated action. We've solved many problems, but don't be fooled, there are more around the corner. What are those issues? What are our strategies to deal with them? What are the solutions? What are the directions we intend to take over the next five years? That is what I hope you will have a successful two days deliberating.

DIOXIN ANALYSIS

Helle Tosine
Manager, Laboratory Services Branch
Ontario Ministry of the Environment

Analytical chemists, in the field of dioxins and dibenzofurans, have the challenge of having to produce data for all the different programs: for the people who are interested in looking at human adipose tissue, at emissions from incinerators, at fish, at water, at toxic waste dumps. We have to be able to provide the data and the data has to be good.

What I would like to do today is quickly give you an overview of the analytical process. Then I will outline some of the weaknesses in the analytical train, and from there discuss the current state of analytical capacity.

In order to understand how we analyze dioxins, you should know that we're looking at a total of 210 different types of dioxins and furans. We don't necessarily have to be able to identify all of them; usually just around 12 of the more toxic ones. The problem is we have to be able to separate these compounds from a variety of other organics in a sample.

This is done using a mass spectrometer. The sample is bombarded by electrons and thus produces ions, which travel to an analyzer and a detector. The detector produces a computer printout based on its molecular weight reading of the sample.

The molecular weight of tetrachlorodioxin is 322. A dioxin with five chlorines on it will have a different molecular weight, and so on.

Dioxin, however, is not the only thing in the world that has a molecular weight of 322. A variety of other compounds are usually found in association with dioxins, such as DDTs, DDE, one of the PCBs - heptachlorobiphenyl - a separate chlorine from the PCB molecules and tetrachlorodioxin. These all have a molecular weight around 322. So the challenge is how to separate out the dioxins from all the other organics and other chemicals with the same molecular weight.

First we have to take a sample and extract all the organics, then remove all the interferences from the dioxin and, finally, analyze it by the mass spectrometry method.

For samples such as fish, we dissolve the fish tissue in acid, which turns a purple colour. When you shake the sample overnight, the organics go into the organics phase, the top phase; we take that phase off. Something solid like an incinerator sample is put into a thimble. The solvent circulates through it and distills, ending up with the organics in the bottom part.

The organics are concentrated and we take those through something called column-chromatography. This is a special type of packing material which has been designed to retain certain organics longer than others. The extracted organics are put on top. Some of the organics get stuck on the column longer than others. You add different solvents and you get PCBs coming out first, then dioxins, then DDE; it's a very crude form of separation. We do this with four different types of packing. It normally takes the analyst around eight working days to get from a solid sample into an organic solvent that contains dioxins. It's a long complicated process. The problem is that we've had to engineer the type of packing for different types of samples. So, for example, for fish, the packing has to be able to retain fats. For incinerator samples where you don't have fats, it has to retain other types of organics. The obvious quest would be towards a universal type of absorbent that can be used to separate any sort of sample.

This work, by the way, is done in batches; we don't do one column at a time. We usually do about 13 to 15 samples at a time. We have methods for soil, sediment, surface water, drinking water, and chemical formulations such as 2,4-D or 2,4,5-T. We're looking at incinerator samples, what goes into the incinerator as well as what comes out; hazardous waste sites, ambient air and food. The capability for sample analysis for these sample types exists in the literature.

After column-chromatography, we have around 10 to 25 microlitres of sample extract; we've been able to get rid of as many PCBs as possible and have something that contains primarily dioxins and/or dibenzofurans. We inject 2 microlitres of this sample into a mass spectrometer. Then we look at each of the signals detected by the computer, figure out which chemical it is and how much is present.

For example, we have the computer software to spread the pentadioxin detection area out to look at whether the signals are in the correct ratio. We have a long complicated criterion; if the sample matches the criterion, it's identified as a positive pentadioxin or pentafurans.

In the case of fish samples, we've tried to get software that would improve the production and the data reading, but so far it hasn't worked adequately. This type of artificial intelligence generally costs a fair amount of money. We're still working on that as a goal.

It takes an analyst about eight days to do the rough clean-up and about three to five days to do the mass spectrometry confirmations. My lab at the Ministry of the Environment analyzes about 1200 to 1500 dioxin samples a year. These would cost around $1,000 - $1,500 a sample if we were to get a private lab to do them, a fairly expensive proposition.

I think it's prudent right now to mention the heavy quality assurance that has to go into this data so that when we produce the numbers, people can stand behind them; when we say that it's 5 ppt, it is in fact 5 ppt.

Quality assurance is concerned with things like what is the precision and accuracy of the data and is the data representative of the true value in the sample. Is it 5 parts per trillion (ppt) or 6.5; or is it 5 ppt plus or minus 2.5? Is the sample a true representation of the whole? When we go out to take a drinking water sample, how are we absolutely sure that this sample is what people really drink over time, and is this sample homogeneous?

For the National Incinerator Testing and Evaluation Program (NITEP), for example, we analyzed the refuse going into a total mass balance incinerator. To produce a homogeneous sample, we had to create a very complicated protocol where we took various big chunks of all the refuse, subdivided this, took small amounts of the subdivision, subdivided that, and ground it all up; it was a very complicated procedure.

As a second example, for Ontario's Municipal Industrial Strategy for Abatement Program (MISA) for end-of-pipe effluent monitoring, you must be able to confidently report data. The analytical chemist has to work with the engineer or the sampler to develop a detailed sampling protocol.

I will now look at all the matrices previously described and discuss where we are in each of these areas for each one of the matrices in Canada. From there it will become evident where work needs to be done.

I'll take a few minutes to describe exactly what I mean: using as an example drinking water sampling protocols. The Ontario Ministry of the Environment has been analyzing drinking water for dioxins since November, 1985, jointly with Health and Welfare Canada. We had to develop a protocol whereby when we analyze drinking water and well water, we are sure that the same block of raw water has moved through the water treatment plant and we're actually looking at exactly the same water, raw and then treated.

Also, when we were out in the field, we had to make sure that the air in the treatment plant wasn't really affecting the data: that the dioxins we found in the raw or treated water weren't coming from the air.

We introduced into the sampling method something called "field blanks" where we took distilled, very pure water, out into the field and poured it from one container to another to expose this water to the air and the environment, then analyzed that as a field blank. We did everything in replicate. When we tested one water treatment plant, we were actually analyzing 130 litres of water to get one data point. It took a lot of time. You can see that the emphasis there would be placed on trying to find a better, quicker method.

For the drinking water analytical protocol, there are parallel problems in the lab: to make sure that we have laboratory blanks, and we're not picking up anything from glassware or the environment in the lab; to make sure that the data we get is really produced by the sample.

Additional data quality assurance can be achieved through frequent inter-agency comparisons: When we put out data for drinking water, can we compare our number directly to the one from New York State or the U.S. Environmental Protection Agency? Are their protocols the same? To be able to do this, we need to run inter-agency comparisons. Dr. Ryan from Health and Welfare conducted one for fish many years ago, where he sent out fish samples to a wide variety of agencies, got the data back and now we can say that we can compare our data to New York State. We need more of this inter-agency comparison for all those matrices that I mentioned before.

We need to be able to analyze the 12 toxic isomers. The United States has been focusing only on 2,3,7,8-TCDD; it's not good enough any more. We must be able to do more than that. We need more data, we need it fast, we need to analyze for a wide variety of matrices, and we need to keep the cost down.

So where are we in Canada? With drinking water, we're doing fairly well here. Currently we're the only people in the world doing drinking water analysis for dioxins. We have the sampling and the analytical protocols in fairly good shape. Inter-agency comparisons: we need more of them. We did quite a few between the Ministry of the Environment and Health and Welfare Canada at the beginning of the program. The data looked very good, very comparable. The detection is adequate, down to 1 part per quadrillion (ppq); it could be a little bit better. By that I mean that we need to go below 1 ppq to be able to say that 1 ppq is good. We are unable to analyse for toxic congeners right now; instead we're doing total congener groups.

When we report data, we refer to total pentadioxin or total pentafuran. We would like to be able to say that there is "X" amount of 1,2,3,7,8-pentafuran or pentadioxin specifically.

The speed of analysis is very slow. Right now we're working on this and the cost which is very expensive.

Incinerator Emissions:

We've done quite a few inter-agency comparisons, and I think the sampling and analytical protocols of Canadian labs are as close to state-of-the art as you can get. Detection is adequate because we always find significant levels of dioxins in incinerators.

We also need work in the area of total toxic congeners. Right now we're analysing total congener groups, as I mentioned before. The throughput and the speed can't be made any better from an analytical point of view, and I think the cost will stay the same.

Biological Tissues:

We've done quite a lot of work in this area. Biological tissues here include human milk, adipose tissue, fish, clams. The analytical protocols are fairly good in this area, too. The inter-agency comparisons: we've done quite a bit of work with U.S. Food and Drug Administration in the fish area and I know that Dr. Ryan has done inter-agency comparisons in the adipose area. Detection is also good. We need work on the throughput and the speed; in most matrices, that's where the problems lie as well as in getting the costs down.

Surface Water and Effluents:

This is to support our Ontario MISA program. In Canada we haven't done a lot of work in this field because we haven't had that much concern. Mostly the Ministry has been involved with inter-agency comparison with the United States in the Hyde Park and Love Canal area.

Hazardous Wastes:.

The Ministry has worked with New York State and the EPA in doing some samples from the Hyde Park/Love Canal area - called NAPL: Non-Aqueous Phase Liquid waste. In a sample we got 7.6 ppb and New York State got 7.8; the data compared fairly well. We've done quite a bit of work in that area. We also need work in the of area of specific isomers; we're only producing total congener groups for them right now.

Soils and Sediments:

The work that we've done here doesn't begin to approach the amount of work that the Americans have done for the Times Beach area. In Ontario, the soils and sediment work has focused on incinerator monitoring. We're also currently involved in toxic precipitation, looking at toxic rain and the effect on soils and sediment. Again, work is needed in inter-agency comparisons and toxic congeners.

Ambient Air:

The U.S. EPA has done a very little bit of work in this area; the method is fairly new. Ontario is just getting into this area. I think we've only done about six samples; it's purely developmental.

Foods:

Jointly with Health and Welfare, the Ontario Ministry of Agriculture and Food and the Ministry of the Environment, have been involved in a program looking at the daily diet in Ontario. The analytical protocol for this particular program is very strong, but sampling protocols could be improved. The downfall here is to be able to track back to the exact source. We've tried to get an overall look at whether there is actually a problem in foods. Very little inter-agency work has been done on the question. Toxic congeners again need work and it's fairly expensive analysis. We can improve in these two areas.

Table 1 is taken from a document that compiled all the research programs for NATO countries. Sweden and Japan aren't included, though they do a lot of work in the area. This is the best available information, though it would only, of course, include those people that responded to the questionnaire. But you can see that in Canada, we're fairly well up there in spending funds on analytical development. We have 16 projects documented

TABLE 1
WORLD-WIDE DIOXIN RESEARCH FUNDING
1985 - 1987 ($,000)

AREA	U.S.A.		GERMANY		CANADA		THE NETHERLANDS		ITALY		U.K.		NORWAY	
	#	$	#	$	#	$	#	$	#	$	#	$	#	$
Surveys Monitoring	6	4,841	5	1,985	15	2,632	7	193	-	-	2	460	1	70
Risk Assessment Toxicity	12	16,849	3	795	6	387	2	197	4	678	-	-	-	-
Formation Clean-up	14	13,082	9	6,455	6	561	1	40	2	116	-	-	-	-
Municipal Incineration	-	-	7	3,993	5	4,967	1	645	-	-	-	-	-	-
Environmental Fate/Transport	10	4,227	-	-	5	354	-	-	1	53	-	-	-	-
Analytical Development	2	590	-	-	16	1,865	1	40	-	-	1	250	1	30
Standard Synthesis	1	180	-	-	2	72	-	-	-	-	-	-	-	-
Phys/Chem. Properties	1	40	-	-	1	16	-	-	-	-	-	-	-	-
Misc.	-	-	1	171	3	311	-	-	1	60	-	-	-	-
	46	39,809	25	13,399	59	11,165	12	1,115	8	907	2	710	6	100

with NATO, so we're putting a lot of effort into that area. We are also leaders in other areas, such as municipal incineration, but there are also areas that we need work in.

To summarize, analytical chemists need to dedicate time to improve analytical capacity for soils and sediments, effluents and surface waters, hazardous wastes, and ambient air. Soil and sediment may not be a problem in Canada; we haven't found it so yet.

Looking at the positive points we are world leaders in drinking water, incinerator emissions and biological analysis techniques. And just lately, because work has not been done in the area, we are also world leaders in analysing food. We have analytical capability for a large variety of matrices, and detection is acceptable or adequate in most of these matrices.

Where do we need work? We need more inter-lab comparisons. We need standard reference materials, such as a type of incinerator flyash that is quantified so that we could use this as a standard to compare, over time, whether our methods are still adequate. We need better statistical sampling, a better idea of whether we're really sampling what would be representative of the problem. We need more data faster: we have to automate, and we need better clean-up, better interference separation, easier ways of doing the samples. We have to go towards toxic congener identification and really need to look at lowering costs so we can keep producing more data.

I hope I've been able to give you an overview of the challenges of analytical chemistry, where we stand in the world area, and where we need more work.

DIOXIN LEVELS IN HUMANS, FOOD AND THE ENVIRONMENT

Dr. Ross Norstrom
Chief, Chemistry Research
National Wildlife Research Centre
Environment Canada

I have an impossible task today: I'm going to try to cover dioxins in everything. I will restrict myself mainly to Canada, however, since that is our main concern and we have a lot of data on Canada.

My co-author is Jake Ryan from Health and Welfare who supplied me with some of his data on levels in humans.

The 2,3,7,8 substituted positions in both the polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs) are the most important ones; since there are 135 PCDFs and 75 PCDDs, it could be very difficult to make toxicological sense of an analysis. In practice, there are only 17 congeners that have 2,3,7,8 substitution, which eliminates quite a number of compounds from our primary toxicological concerns.

We also have information on relative toxicity, mostly from _in vitro_ testing, but also from a growing body of _in vivo_ testing. We know that the PCDDs are more toxic than the PCDFs and that, as chlorines are added to the molecule, the toxicity tends to go down. So, in fact, we're mostly interested in the less chlorinated 2,3,7,8 substituted dioxins and furans, of which there are 12.

The Summary of Major Sources (Table 1) is just to give you an idea of where things may be coming from. These are the main possible sources to the environment in terms of the fact that they're wide-use chemicals or wide-use processes and, therefore, likely to be the major contributors to the ambient environment.

Pentachlorophenol is a very major-use chemical worldwide for wood treatment and other purposes. It contains mainly non-toxic PCDDs and PCDFs but it does contain reasonably high levels -- or some old formulations did - of the toxic hexa PCDDs.

TABLE 1
SUMMARY OF MAJOR SOURCES

SOURCE	PCDDs		PCDFs	
	TOXIC	NON-TOXIC	TOXIC	NON-TOXIC
PENTACHLOROPHENOL	++ (6 Cl)	+++	-	++
2,4,5-TRICHLOROPHENOL	+++ (4 Cl)	+	-	-
PCB (AROCLORS)	-	-	+++ (4-6 Cl)	++
COMBUSTION	++ (4-6 Cl)	++	++ (4-6 Cl)	++

NOTE: Combustion incudes any processes where there is a chlorine source, e.g., municipal waste incineration and burning gasoline with chloroethane scavengers.

2,4,5-trichlorophenol, of course, is notorious for having contained 2,3,7,8-TCDD.

PCB mixtures (Aroclors) have been shown to contain parts per million levels of tetra- to hexa-PCDF. There are no dioxins in PCBs unless they're burned.

And then, of course, combustion, the most recently discovered source. Combustion is a source of a wide range of PCDDs and PCDFs in which the toxic isomers are not usually the most important within the group, and this has caused, of course, some difficulty in trying to interpret environmental consequences.

As you can see in Table 2, in air we typically have something like a half a picogram PCDD per cubic meter, so that's 10 to the minus 12, pretty small, although it is measurable with current analytical technology.

TABLE 2
LEVELS AND SOURCES OF PCDDs AND PCDFs IN THE AMBIENT ENVIRONMENT

ENVIRONMENT	AVERAGE AMBIENT LEVEL (PUTATIVE SOURCE)	
	TOTAL PCDDs	TOTAL PCDFs
AIR	0.5 pg/m^3 (COMBUSTION)	0.3 pg/m^3 (COMBUSTION)
AIR PARTICULATES	1 pg/m^3 (COMBUSTION)	0.01 pg/m^3 (COMBUSTION)
RAIN	60 ppq (COMBUSTION)	10 ppq (COMBUSTION)
SURFACE WATERS	1 ppq (UNKNOWN)	1 ppq (UNKNOWN)
SEDIMENTS:		
(Great Lakes, Swiss lakes)	2 ppb (COMBUSTION, CHLOROPHENOL)	0.1 ppb (COMBUSTION, AROCLORS)
(Rhine River)	3 ppb (CHLOROPHENOL)	1 ppb (CHLOROPHENOL)

Particulates have somewhat higher levels, particularly for the higher chlorinated dioxins.

Rain has 60 to 10 parts per quadrillion (ppq) levels in it, because it's washing these materials out, so it tends to have rather higher levels than surface waters, which generally have less than 1 ppq of any individual or combination of dioxins.

Sediments have been studied in a number of areas, and apart from highly contaminated areas with known sources of dioxins and furans, a typical range is part per billion or fractional part per billion levels, mostly of higher chlorinated congeners, and usually attributed to combustion.

More recently, people have been looking carefully at the individual isomers in some of these fractions. Hagenmaier in Germany has concluded that most of the PCDDs that he sees in sediments in the Rhine River and the Neccar River and several other rivers in Germany have, in fact, a chlorophenol source.

So we have, in a sense, a competition between combustion and chlorophenols as the putative sources for what PCDDs and PCDFs one actually sees in the environment.

Table 3 lists the results from some of the most recent analyses by the Canadian Wildlife Service. In British Columbia we have found some 2,3,7,8-TCDD in crabs' hepatopancreas because the crab tends to accumulate PCDDs rather more readily than most animals. However, the leg muscle, that part you eat, didn't have anything in it. Most of the edible

TABLE 3
2,3,7,8-TCCD LEVELS IN CANADIAN WILDLIFE

AREA	YEAR	SPECIES	TISSUE	LEVEL (ppt)
BRITISH COL.	1984	DUNGENESS CRAB	HEPATOPANCREAS	2 - 3
			LEG MUSCLE	2
	1986	GR. BLUE HERON	EGG	3 - 170
	1985	ENGLISH SOLE	WHOLE	2
	1985	PINK SALMON	WHOLE	2
MANITOBA	1981	R.N. GREBE	EGG	17
ONTARIO	1986	HERRING GULL	EGG	15 - 65
	1986	SMELT	WHOLE	2 - 7
	1976	COHO SALMON	EGG	42
	1985	TURTLE	LIVER	32 - 107
QUEBEC	1986	GR. BLUE HERON	EGG	4 - 17
	1982	EEL	MUSCLE	2 - 23
NEW BRUNSWICK	1982	MINK	LIVER	2
	1982	HERRING GULL	EGG	7
NOVA SCOTIA	1982	BALD EAGLE	EGG	11 - 13
NEWFOUNDLAND	1971	BALD EAGLE	EGG	21
NORTHWEST TERR.	1982	POLAR BEAR	LIVER	2 - 20

fish had below detectable levels. But we did find that great blue herons, which are a fish-eating bird resident in that area, were quite contaminated in some locations. In fact, the B.C. heron population has probably the highest overall PCDD levels we've seen yet in Canadian wildlife.

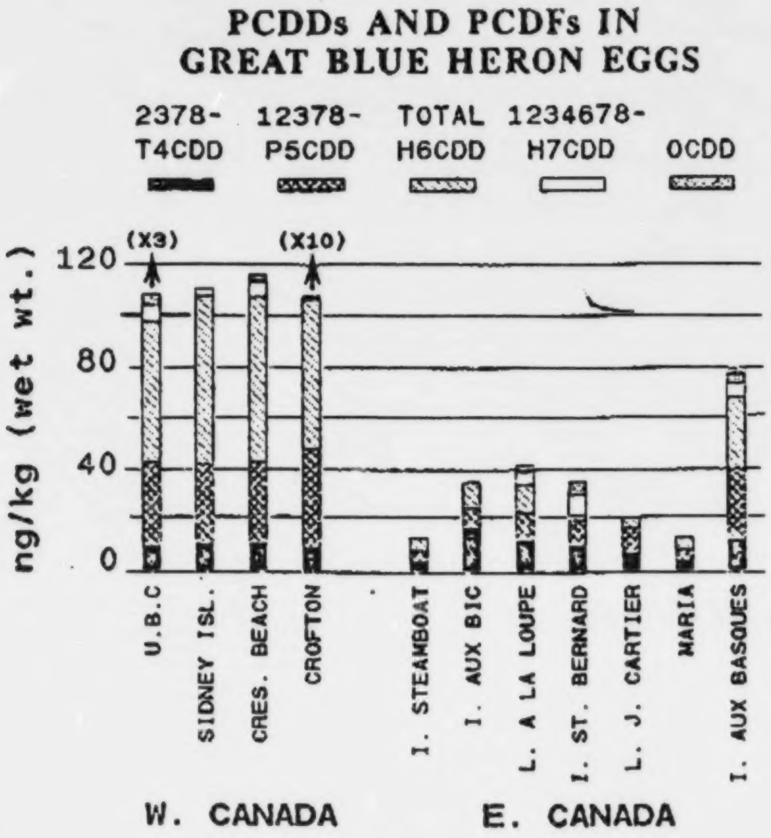
Various samples of other fish-eating birds and aquatic animals taken across Canada typically show something in the less than 100 parts per trillion (ppt) range. And when you get into Ontario, you're really dealing with samples in the Great Lakes where there are known sources.

We have just analysed eggs of the non-resident population of blue herons in Quebec. The levels were a lot lower than those found in British Columbia. We've looked at mink, which are a fish-eating animal, in the areas where 2,4-D was sprayed in New Brunswick, thinking we might pick up the particular dioxins that were present there. We didn't find them. However, animals that are quite far up the aquatic food chain, like polar bears in the Arctic and bald eagles, do in fact contain measurable levels of 2,3,7,8-TCDD and perhaps a little bit of octa dioxin, but nothing else. We have a very strange situation here, but clearly 2,3,7,8 is ubiquitous.

Graph 1 shows the heron results, just to give you a concept of the differences between areas. In British Columbia, the eggs from the UBC campus were at a level three times higher than the scale on the left and levels at Crofton, where there's a large mill, were actually ten times higher. In this case levels were high enough, in sensitive species, to possibly cause reproductive failure. So we're concentrating quite a bit of effort in this area.

Notice, however, that at all sites in British Columbia the relative amount of the PCDDs is pretty much the same. So we believe that there is a single source. I think this source is chlorophenols, but there is a lot of work to do there yet.

GRAPH 1



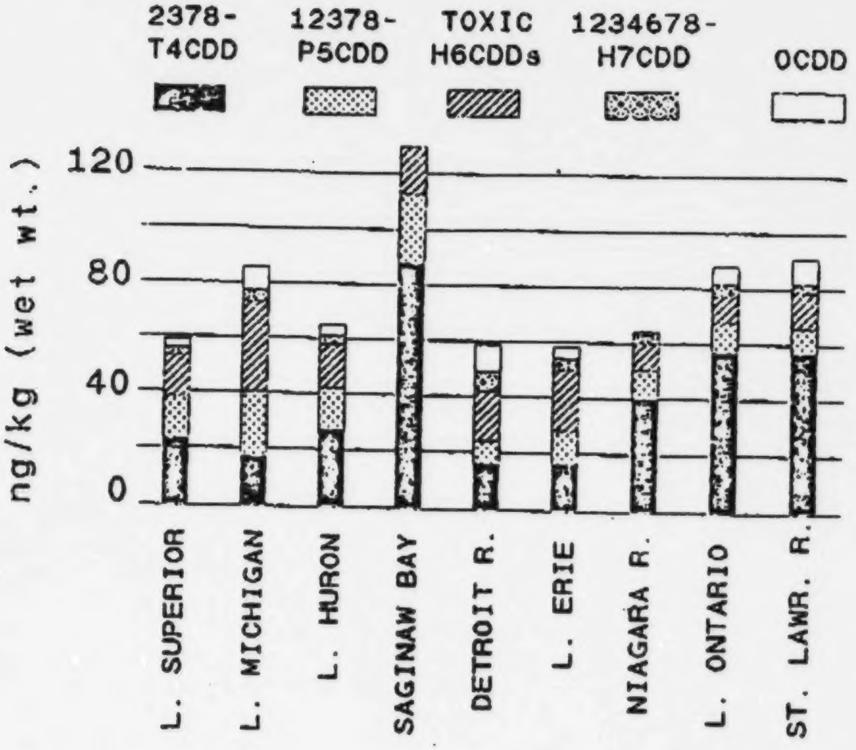
Among heron eggs from various parts of Quebec, there was no particular rhyme or reason to the pattern of dioxin contamination. Some of the eggs were taken on or near the St. Lawrence. Yet, the most highly contaminated one, I believe, is not even from near the St. Lawrence River.

Overall, the contaminant levels are similar to other fish-eating birds here and not particularly high. So the high levels in B.C. herons are unique.

The other area where the Canadian Wildlife Sevice has done quite a bit of work is analysis of herring gull eggs in the Great Lakes. Graph 2 shows the situation in 1986, to give you an idea of the distribution of levels in the Great Lakes. In fact, there isn't anything to get terribly excited about at the moment. Lakes Superior, Michigan and Huron, the Detroit River, Lake Erie and even to some extent the Niagara River are at pretty much background levels. Most of this is probably due to atmospheric input to the lakes. With this kind of source, you don't expect to see big differences between areas.

GRAPH 2

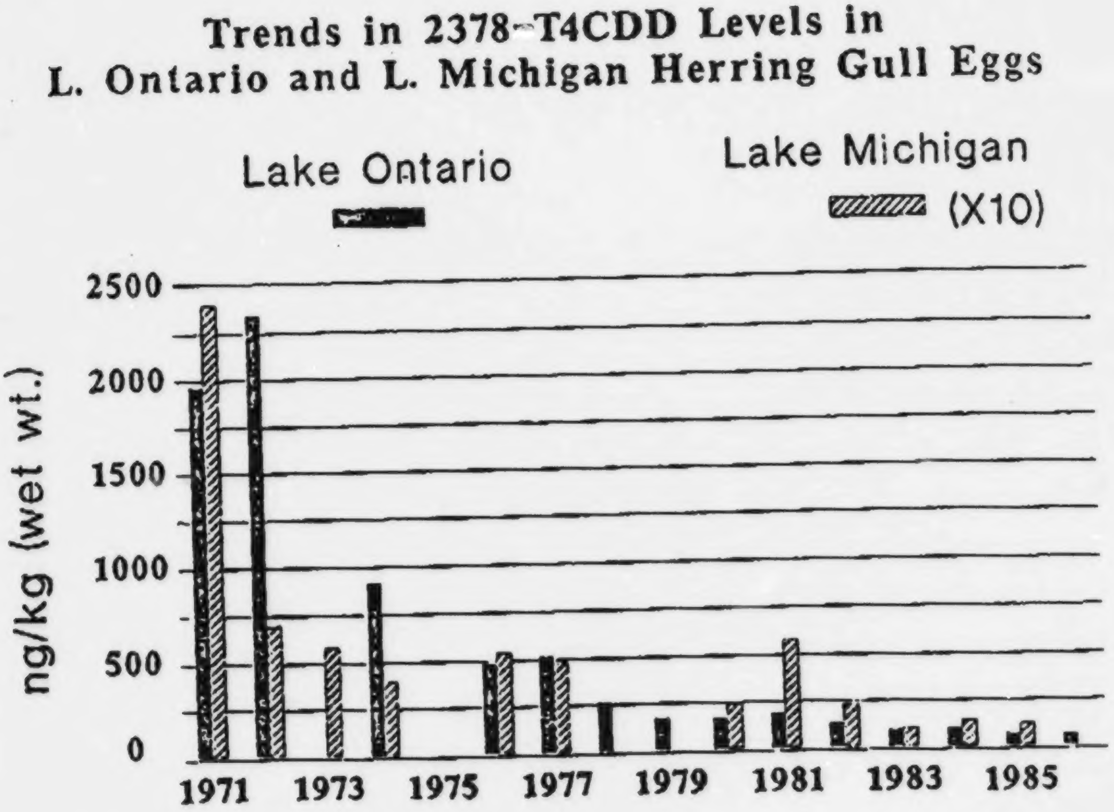
PCDDs IN GREAT LAKES HERRING GULLS, 1986



Lake Ontario, the St. Lawrence River, Saginaw Bay and to some extent the Niagara River still have elevated levels of 2,3,7,8-TCDD, but not more than about two-fold background. Things appear to have improved a lot in those areas.

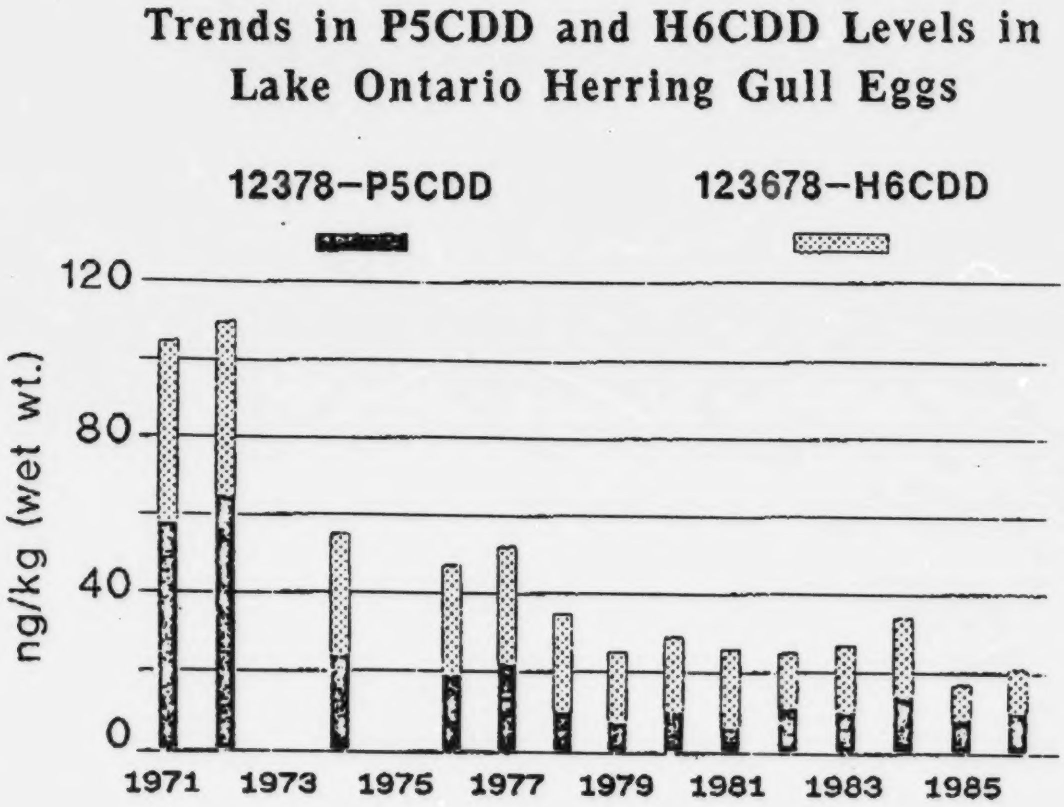
Graph 3 gives you an idea of the trends in 2,3,7,8-TCDD levels for two lakes throughout the years. These are samples that were analyzed from our tissue bank. Lake Michigan levels are quite a bit lower; the scale is a factor of ten lower to start with and there really is only one high point in 1971. So, in fact, Lake Michigan never did have much of a problem with 2,3,7,8-TCDD but Lake Ontario obviously did, with levels up around 2 to 2.5 ppb in the early 1970s. Along with many other organochlorines, these levels have come down, with a half-life of two or three years, and are continuing to go down. So there's no evidence from our data that any 2,3,7,8-TCDD is leaking into Lake Ontario right at the moment.

GRAPH 3



The penta- and hexa-CDDs in Lake Ontario herring gull eggs also decreased in the early 1970s, although more slowly than 2,3,7,8-TCDD (Graph 4), which leads me to believe that there was an industrial component to this contamination prior to 1978.

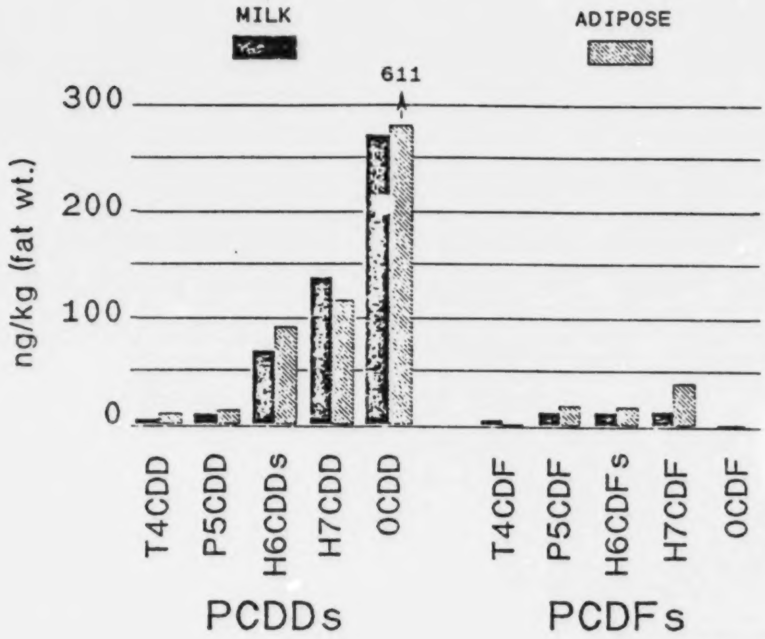
GRAPH 4



Moving on to humans, Health and Welfare Canada's analysis reveals in Graph 5 that human adipose tissue and milk on a fat weight basis have pretty much the same concentration of PCDDs and PCDFs except for OCDD, which tends to be higher in fat. These contaminants are at equilibrium between the various fat pools in the body and move around according to where the fat goes. The levels of 2,3,7,8-TCDD are relatively low, less than 10 ppt on a fat weight basis in both adipose tissue and milk fat.

GRAPH 5

PCDDs AND PCDFs IN CANADIAN HUMAN MILK AND ADIPOSE TISSUE

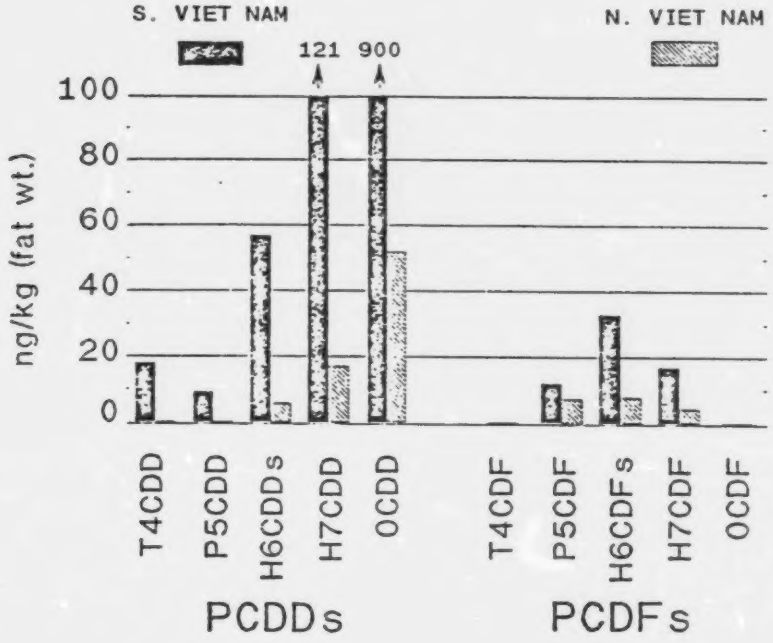


Graph 6 deals with an interesting study in which Health and Welfare Canada was also involved in, where adipose tissue from North and South Vietnam was analysed. In addition to Agent Orange having been sprayed in South Vietnam, one supposes that the presence of the Americans affected agricultural practices and everything else, in the process introducing a goodly number of other chemicals, such as pentachlorophenol. There would be less chemical use in North Vietnam, which was much poorer, much more isolated. Low chemical levels have also been found in people in China.

So although to some extent the pattern looks the same in all humans, the levels in industrialized countries are very much higher, which means that dioxin levels are not just due to general combustion. You wouldn't see this kind of distribution.

GRAPH 6

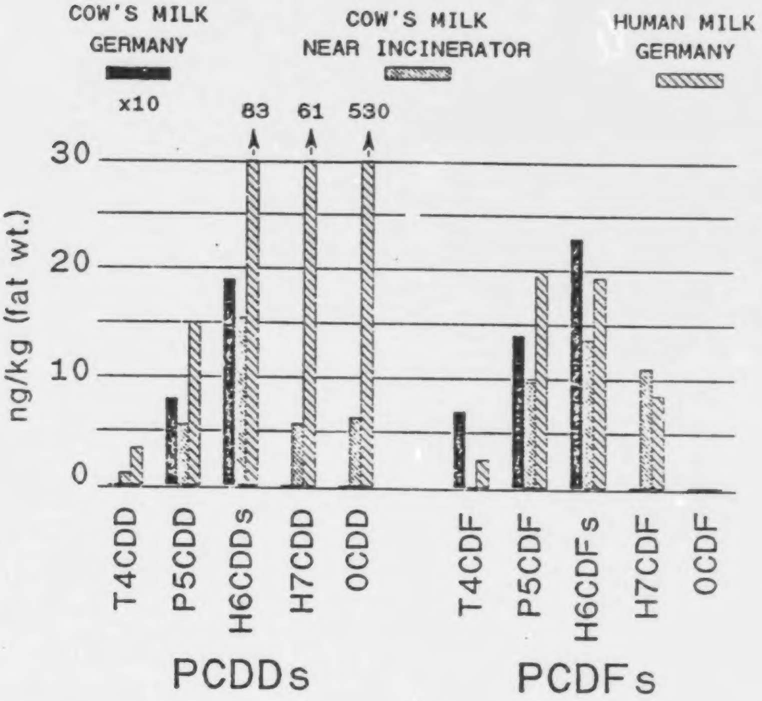
PCDDs AND PCDFs IN HUMAN ADIPOSE TISSUE FROM NORTH AND SOUTH VIETNAM



We're now starting to get some comparisons between cow's and human milk, mostly from Germany. We have three sets of data in Graph 7: there is cow's milk from all over Germany and cow's milk from an area where the cows were grazing near an incinerator. These show the average and the worst-case situations. In practice you get higher octa- and heptadioxins in the cows grazing near the incinerator, but there didn't seem to be very many other differences. There's practically no detectable level of TCDD in ordinary cow's milk; near the incinerator there was a little.

GRAPH 7

**PCDDs AND PCDFs IN
COW'S AND HUMAN MILK IN EUROPE**

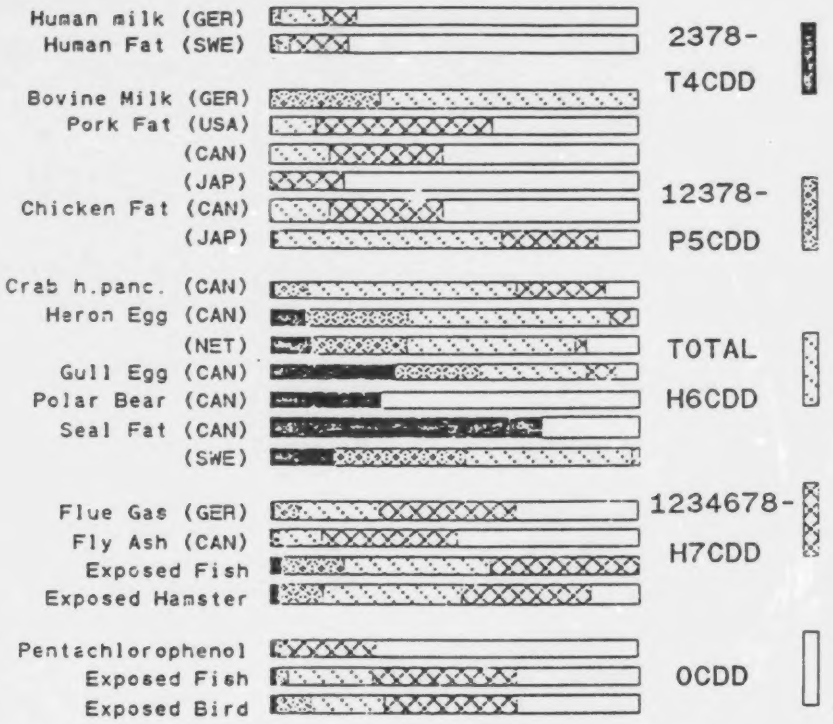


Graph 8 shows the percentage distribution of the toxic PCDDs, grouped according to number of chlorines, in sources, humans, human food and wildlife. There is an example of flue gas and fly ash and fish and hamsters exposed to this type of combustion source. The pattern is preserved reasonably well in the animals, except that there is less OCDD.

At the bottom of the graph we have a situation where fish and birds were exposed to pentachlorophenol sprayed in a marsh in the early 1970s, compared to the PCDD contamination in present-day pentachlorophenol. The big differences between pentachlorophenol and the animals are that OCDD is lower, and hexa-CDDs and penta-CDDs are higher in the animals. So it appears that even though pentachlorophenol is not supposed to contain penta and tetra-CDDs, they must have been present - at least in the old formulations.

GRAPH 8

RELATIVE LEVELS OF PCDDs IN HUMANS, SOURCES AND ENVIRONMENT



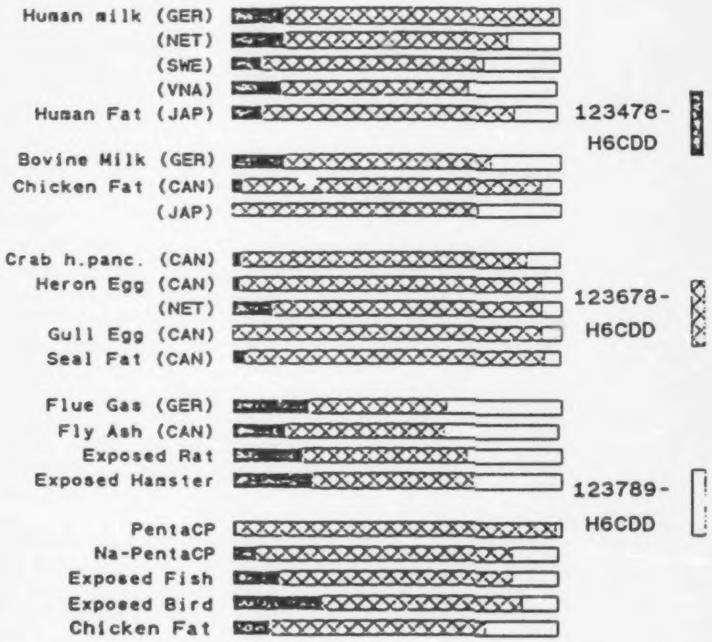
The differences in PCDD contamination in animals exposed to combustion and to pentachlorophenol sources is not as different as we would expect from analysis of sources, therefore it is a complicated business determining sources of exposure.

Among the wildlife samples you can pick out a few distinctive patterns: the polar bear and seal fat, for example have a relatively large amount of 2,3,7,8-TCDD and some OCDD, but nothing else.

I attempted to sort out the problem of sources, using the ratios of hexa-CDDs (Graph 9). In the case of pentachlorophenol, we have a situation where one particular isomer seems to dominate. In combustion sources, the isomer is not so dominant.

GRAPH 9

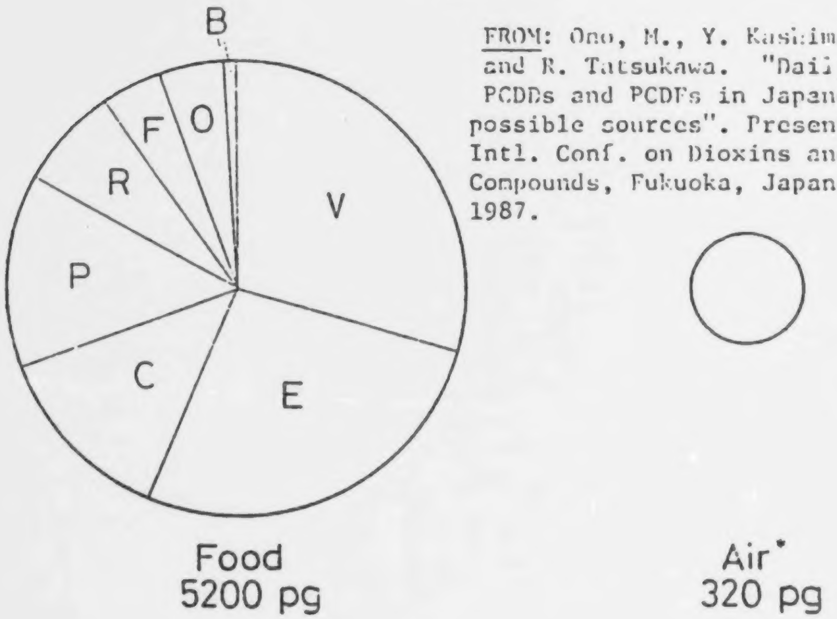
RELATIVE LEVELS OF THE THREE
TOXIC H6CDD ISOMERS
IN HUMANS, SOURCES AND THE ENVIRONMENT



Once again, when you feed the isomers to animals, the patterns are pretty well preserved. However, the patterns are not so different that identifying a source with them is definitive. Taking a look overall, it appears that the source in humans is more like chlorophenols, but it may not be true in all areas. We are faced with the possibility that both sources are important.

I heard an interesting study on levels in foods presented by Professor Tatsukawa's group at a dioxin conference in Japan last year. This is the only reasonably valid and comprehensive study on levels of dioxins in the human diet to date. They took a large number of samples, and then determined the PCDDs in each of them. Graph 10 shows how the PCDDs split up among food groups. They did calculations comparing air to food, and came to the conclusion that food is relatively more important. Vegetables, chicken eggs, chickens and pork contributed the great majority of the PCDDs present, though most of these dioxins are non-toxic. In this case, the Japanese herbicide *CNP is the source of the less toxic tetra-isomer dioxins.

GRAPH 10



FROM: Ono, M., Y. Kashima, T. Wakimoto and R. Tatsukawa. "Daily intake of PCDDs and PCDFs in Japanese and their possible sources". Presented at the 6th Intl. Conf. on Dioxins and Related Compounds, Fukuoka, Japan, Sept. 16-19, 1987.

COMPARISON OF DAILY INTAKE FROM FOOD AND AIR

* Calculated from Environment Agency data

V: vegetable E: egg C: chicken P: pork
R: rice & wheat F: fish O: plant oil
B: beef

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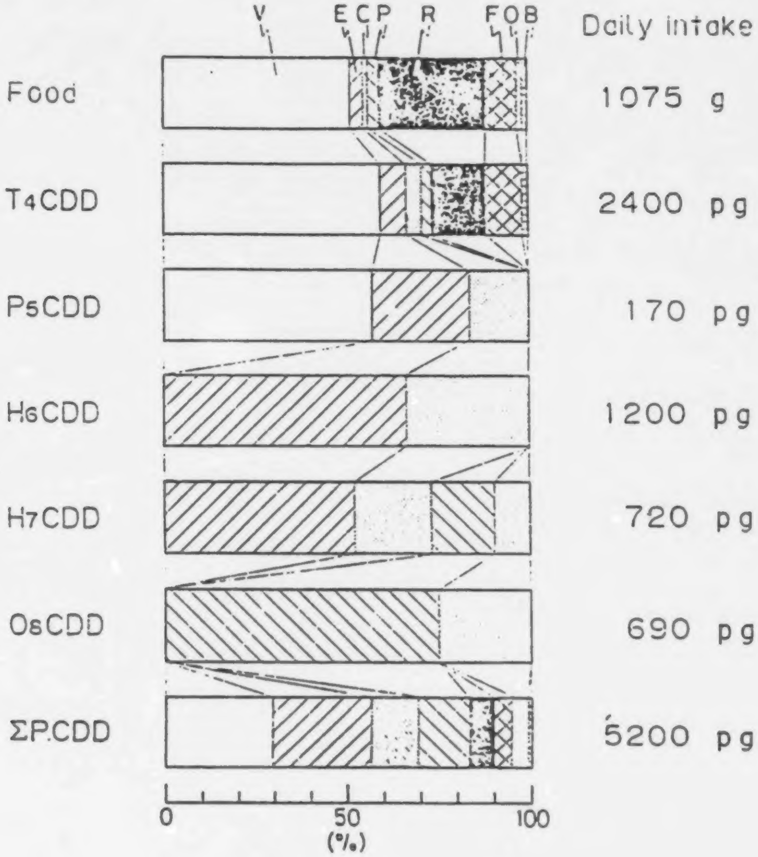
* Not used in North America

Graph 11 gives you a detailed breakdown by homolog of the possible routes; here again we see fairly important contributions of tetra-CDDs from vegetables and hexa-CDDs from eggs.

GRAPH 11

FROM: Ono, M., Y. Kashima, T. Wakimoto and R. Tatsukawa. "Daily intake of PCDDs and PCDFs in Japanese and their possible sources". Presented at the 6th Intl. Conf. on Dioxins and Related Compounds, Fukuoka, Japan, Sept. 16-19, 1987.



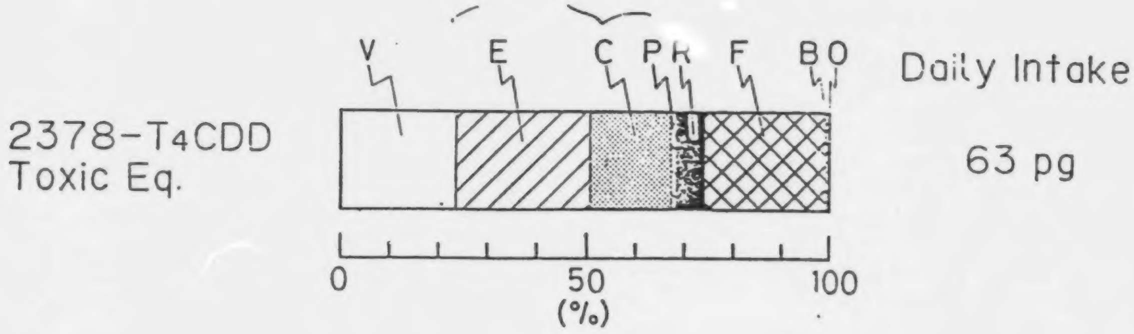
DAILY INTAKE AND COMPOSITIONS OF FOOD AND PCDD CONGENERS

V: vegetable
E: egg
C: chicken
P: pork
R: rice & wheat
F: fish
O: plant oil
B: beef

FROM: Ono, M., Y. Kashima, T. Wakimoto and R. Tatsukawa. "Daily intake of PCDDs and PCDFs in Japanese and their possible sources".

The Japanese researchers also did a toxic equivalency calculation and tried to split that up among the various food groups. They came to the conclusion that fish, chicken, eggs and vegetables all made roughly equal contributions to dioxin toxicity in the Japanese diet, as shown in Graph 12. We wouldn't expect those data to apply here, but the Japanese study is a good model to emulate.

GRAPH 12



ESTIMATED DAILY INTAKE AND COMPOSITION OF
2,3,7,8-T_4CDD TOXIC EQUIVALENT

V: vegetable E: egg C: chicken P: pork
R: rice & wheat F: fish B: beef O: plant oil

(1.3 pg/kg body weight/day for a person weighing 50 kg)

FROM: Ono, M., Y. Kashima, T. Wakimoto and R. Tatsudawa. "Daily intake of PCDDs and PCDFs in Japanese and their possible sources". Presented at the 6th Intl. Conf. on Dioxins and Related Compounds, Fukuoka, Japan, Sept. 16-19, 1987.

Let me give you a few conclusions, some of which are more firm than others. Contamination in Canadian wildlife is highest in the Great Lakes and in great blue herons in B.C., but the levels have improved a lot since the 1970s in Lake Ontario. In B.C., we're not sure whether what we're seeing is due to the many years of use of chlorophenols with perhaps a different makeup of PCDD contaminants, or whether it has something to do with current factors. A lot more work needs to be done in that area.

It appears probable that combustion, chlorophenols and Aroclors are all important sources of PCDDs and PCDFs in the environment.

Recently aqueous chlorination has come under investigation as a dioxin source and the importance of kraft pulp mills and dioxin loading must now be considered.

Chlorophenol use and wastes, and Aroclors discharging into aquatic environments probably explain the Lake Ontario and B.C. heron "hot spots".

In remote environments, such as the Arctic, 2,3,7,8-TCDD is the major PCDD. This may be due to specific accumulation of that isomer in the food chain, but it may also indicate the relative importance of TCDD in global contamination. And if it is that important, perhaps 2,4,5-T historical uses were the major contributor, since this was once a heavily used herbicide.

More emphasis needs to be placed on monitoring specific PCDD and PCDF congeners in primitive biota, such as crustaceans, shellfish and worms, which accumulate PCDDs and PCDFs less specifically than fish, birds and mammals. Most of the data that we have, as you've seen, are not usable to determine the source. The isomers that may be present in the source, but not accumulated by the fish, are the ones that could tell you whether the source is definitely combustion or definitely chlorophenol.

There is some evidence to believe that analysis of primitive animals will give you that information. Some more work needs to be done here. Then we can start sorting out what the sources are.

My current literature sources indicate -- and some people here may have data to the contrary -- that animal products are the most important route for exposure of humans to PCDDs and PCDFs. Pork, chicken and egg products contribute the most, and that's the higher chlorinated dioxins, the mostly non-toxic ones. A better estimate is required on the role of fish. Current risk-analysis calculations on fish assume that everybody in Canada eats 16 grams of Great Lakes fish a year, which could well be invalid.

Pentachlorophenol and related chlorophenols are likely to be the primary source of the 7 and 8 chlorine PCDDs which are dominant in humans -- that's a tentative conclusion -- and have some potential as sources of the toxic PCDDs, including TCDD. Recent studies in Germany* have shown that old formulations of sodium pentachlorophenate did in fact contain low but measurable levels of 2,3,7,8-TCDD and 1,2,3,7,8-PCDD.

A disproportionate amount of effort has been devoted to studies of combustion sources. We have a tremendous amount of information now on combustion and what role it plays. Yet we still have practically no data on levels in the ambient environment, and the human food apart from fish in the Great Lakes, and the human food. We need many more data on levels of specific congeners in total diet. Because of the long half-life of TCDD in humans, I calculate that we would need roughly .04 ppt in the diet to explain the average level in the Canadian population, and that is generally below the usual analysis detection limits.

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* This manufacturing process was never used in Canada.

DIOXIN SOURCES - COMBUSTION

David Hay
Chief, Urban Activities Division
Industrial Programs Branch
Environment Canada

The subject I've been asked to address this morning is combustion in relation to dioxins. Martin Boddington earlier mentioned the Dow theory, that most combustion processes are at least potential sources of dioxin; I think that much of the literature to date has generally confirmed that hypothesis.

What I'd like to do is take a look at some combustion sources. We have various processes for the combustion of municipal solid waste. We have combustion systems that treat the residues from our waste water treatment processes. We burn coal to produce power and we have motor vehicles powered by fuels requiring combustion. We need fuels to create heat for residential and commercial purposes. Then we have some more rather basic technologies for the recovery of metals, such as copper, ~~through~~ from transformers and wire in a very primitive but effective process.

All of these are sources of dioxin. A few years ago, Environment Canada surveyed the literature and attempted to identify different sources and quantify them in some general sense. The goal was to determine where the problem was the greatest so that some control could be exercised. Table 1 lists the results of this survey; it identifies municipal incineration as one of the larger sources.

For municipal solid waste combustion, different technologies can be applied in different ways to achieve combustion. The consequence is quite a large spread in the amount of dioxin that one could project being released into the environment.

TABLE 1

ESTIMATED PCDD RELEASES TO THE ENVIRONMENT FROM COMBUSTION SOURCES

SOURCES	RELEASE gm/yr
Municipal Incineration	250 - 13700
Sewage Sludge Incineration	1400 - 3300
Coal Fired Utility Boilers	300
Woodfuel Combustion	800
Residential Oil Combustion	1
Residential Gas Combustion	900
Railway Ties	6000
Forest Fires	58700
Cigarette Smoke	2404
Motor Vehicle Emissions	200
Biomedical Incinerators	50 - 80

In fact, since the time these numbers were generated, you can take the lower figure down two more orders of magnitude and double the top number, so we're talking about a range over about five orders of magnitude that one potentially could identify as a level of emissions from one source of combustion for one type of material (municipal waste).

With sewage sludge incineration, again we're talking about a range, depending upon the technology and the operation of the system. Once again, recent information has extended this in the right direction, which is downward two orders of magnitude, so again we're looking at a four order of magnitude variation which one might expect from this combustion source. This table of data should be assessed from the point of view of what is potentially controllable, what is man-made: these things we can do something about.

Motor vehicle emissions: it is possible to control this. There was some work done in Sweden, which compared the use of leaded fuel and non-leaded fuel, with and without catalytic converters on motor vehicles. And when all was said and done, leaded fuels used in cars without catalytic converters produce dioxin; non-leaded fuels and catalytic-equipped cars did not. This is added fuel for the argument of "getting the lead out"! Additional work is being done in this area.

Biomedical incinerators: again, this is an area where there is an increasing interest and more work is being done.

In summary, there's quite a range of potential release levels, and through activities such as this we're able to get some idea of where we perhaps should spend our efforts in looking at combustion sources.

Our friends to the south have done, under their dioxin program, examinations of various dioxin sources. They were largely looking at only dioxin, and they were usually only looking at one or two specific sites for each source category; they didn't attempt to characterize that source and multiply it times the number of plants across the country to get a national picture.

They selected their sites on the basis of the types of combustion systems they would expect to find some dioxin in; and not surprisingly they did find it. But again there's quite a range of results. Looking at sewage sludge incineration: three different types of sludge, three different kinds of combustion systems, and three different numbers.

Wire reclamation incinerators: obviously there's an effect from the combustion technology, but some slight modifications to the fuel had a significant impact on the amount of dioxin that was emitted.

Now I'll talk about the National Incinerator Testing and Evaluation Program (NITEP) a little and try to indicate what we have learned about the combustion of municipal solid wastes as it might relate to other combustion sources.

The Prince Edward Island Energy-From-Waste plant in Parkdale, P.E.I., is a fundamental technology that burns garbage, as received, in small modular systems. We tested it for a series of different conditions. The system has what you would call the normal operating criteria set of conditions and we attempted to vary those conditions, so we went to both extremes: the best we could do and the worst we could do and still have it function as a refuse Energy-From-Waste facility. For all of those conditions the emission number, although varying, is relatively consistent. Conditions which we would generally expect to produce better combustion gave us the lowest number; conditions under which we would expect the worst combustion gave us the highest number. So, for this type of technology combustion, conditions themselves will have an impact on what is going up the stack in terms of dioxins.

We looked at all the homologous groups; we did not deal with specific isomers of each except for the tetras. But for all the conditions we looked at, although there were some small variations, it was relatively consistent for each of the test conditions. There was no significant variation due to combustion conditions in terms of the fingerprint of the dioxin emission.

I think there are fundamentally four theories that one can use to try to explain why we get dioxin from combustion. One is that the raw material contains dioxin that is not completely destroyed in the process. The second is that you have various organic species, PCBs for example, which can give you dioxin during the combustion process. The third is that organic materials, when burned in the presence of chlorine, can lead to dioxins. And then there's a bit of all three that can be catalytically induced to react on the surface of flyash, for example, which is fairly reactive from a catalytic point of view.

We had an opportunity to find out some interesting information in P.E.I. The system has an incinerator, boiler and stack and, with the assistance of Ontario, we were able to put a sampling device immediately after the combustion unit in addition to the one that we had on the stack. What we observed is that after the combustion unit, which we call the boiler inlet, in three of the conditions where we did this particular piece of work, we found either no dioxin or very low levels. However, at the stack, we found at least an order of magnitude increase in the amount of dioxin present. So the combustion process itself is not necessarily producing the dioxins. There are reactions taking place. It is postulated that this is happening in the boiler as you're cooling the gases down. I think this is relatively important. If you look at the chemistry of dioxin and the temperature at which you should be destroying it, those are conditions that do exist in this incinerator and the technology is such that you do have a secondary chamber which is a good burn-out component of the combustion process.

The combustion process itself, as I said, has a major influence on what is going up the stack. One incinerator, which is located about a quarter of a mile east of here in Quebec City, was tested by Environment Quebec in 1984 on three occasions. The emission levels were in the range of 800 - 4,000 total dioxins. About a year and a half ago, the Communaute Urbaine de Quebec (CUQ) spent a considerable amount of money to upgrade the combustion process.

As a result of these improvements, we now have a level of dioxin emission which is down by an order of magnitude and, in some cases, two orders of magnitude. This is solely through improvements to the combustion process.

Even on this new system, we were able to operate in such a way that we could identify good and poor combustion conditions; the consequence of poor operation was higher dioxin emissions.

Irrespective of whatever the combustion process does in many combustion systems, we're not able to achieve what we would call "acceptable" emission levels.

Consequently, we looked at emission control systems which consisted of a scrubber that injected water and lime into a gas stream from the Quebec Energy-From-Waste plant, and a fabric filter, which took the particulate material out. We sampled it before and after each of these devices. Overall, the emission control system was extremely effective in cleaning the gases from this facility.

There are several points to note. First, the conditions that we operated under are differentiated from each other largely by temperature. There is a range of temperature over which we have similar patterns. The pattern could be characterized by saying that a little more than half of what is trapped comes out in the scrubber; the balance comes out in the particulate removal device, in this case the fabric filter.

However, under some temperature conditions, the scrubber isn't doing anything. You're totally dependent upon your particulate removal device for the removal of dioxins, so that for combustion processes, in most cases, control technologies need to be developed and applied, and you need to understand what the system is doing if you're to design and operate it properly.

What have we learned in NITEP? There are a lot of combustion sources; energy from waste is one. I think Canada has spend about $8 million so far on energy from waste. It's an expensive proposition. We can't afford to do that for every combustion source that may emit dioxin. We have to develop a better understanding of the other combustion sources, but I think we have a rough idea of the priority in which we should be looking at them. We have spent a lot of effort and it's expensive work, but we have an indication of the depth that is required on the analytical side to give us viable numbers.

We know that combustion optimization can reduce the amounts of dioxin present. A lot of the systems that are in use today are technologically backward, and we should be looking at either eliminating or improving these sources.

Control devices are required in most cases; not always for dioxin, but for a variety of reasons. When we're talking about combustion sources, it's important to understand how a particular control device is going to respond to that combustion source, in order to be able to design and operate it properly.

Right now, under CCREM, we're involved in the development of a guideline for energy from waste. In looking at how one deals with dioxins, you've heard the term "toxicity equivalent factor". You take all the dioxins and furans together, multiply them by various numbers, depending upon which jurisdiction you're in, and you come up with a number which says it's all there, it's 2,3,7,8-TCDD; that's how much we have.

The public is confused about dioxins. When they look at guidelines and regulations, they find that a figure generated by a Canadian jurisdiction does not seem to match a guideline from Sweden, for example.

The system of calculation used by the two countries is different. The fact that the two numbers mean the same thing is not necessarily understood by the public.

So when we talk about criteria for combustion sources, the toxicity equivalent approach is the one that will be used. It's necessary for, I think, this body and CCREM to address which avenue we are going to pursue. We have a proposed approach and we have other alternatives. It doesn't seem possible that the world is going to come to a consensus on which one to use, but we have to make our decision and we have to make it very quickly.*

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* Recently international agreement has been reached on a single set of toxicity equivalent factors.

DIOXIN SOURCES - PESTICIDES

Laurence McClelland
Antimicrobial Evaluation
Pesticides Directorate, Agriculture Canada

I would first like to thank those responsible at CCREM for extending the invitation to Agriculture Canada to participate in this workshop. I am personally hopeful that by the end of our discussions tomorrow, we will all have not only a better grasp of the overall picture of dioxin sources in Canada but also -- and I think this is equally important -- an understanding of what challenges we each face in our efforts to set further controls.

In preparing for this workshop, I thought it would be useful to review the plan that Agriculture Canada set out, perhaps as long as 17 years ago, to gain control of dioxin contamination of pesticides; and then to follow that by a brief description of some of the efforts we have made to date on specific compounds.

First, the plan. The goal of our original plan was very simple: to have the ability to set and enforce meaningful and realistic standards for dioxin content in pesticides that are registered under the authority of the Pest Control Products Act.

As many of you know, to set such a plan in motion faces a number of hurdles that are substantial and must be addressed. These include acquisition of state-of-the-art analytical equipment, sufficient person-years to operate the equipment and, obviously, experienced operators. There was considerable administrative effort in Agriculture Canada through the seventies to bring all these requirements together, and the result now forms the Mass Spectrometry Laboratory of Laboratory Services Division.

Our first analyses were, of course, directed to 2,4,5-T for the presence of 2,3,7,8-TCDD, for obvious reasons. With increasing experience and confidence (which is vital as a regulator) in our ability to analyze, Agriculture Canada proceeded to set, in 1979, one of the first regulatory standards in the world. The maximum -- and this is rather naive by today's standards -- was 100 ppb of 2,3,7,8-TCDD in 2,4,5-T or fenoprop, which most of you know are herbicides.

Now, having attained a certain degree of control of TCDD in 2,4,5-T, we then directed our resources and efforts to investigate other phenoxy herbicides that were registered in Canada. As a result of efforts through 1979 and 1980, we discovered dioxins other than 2,3,7,8-TCDD in 2,4-D. These 2,4-D analyses were followed by a program to determine the levels of dioxins in tetra- and pentachlorophenol that was being used in Canada. We were simply following a relative priority in our investigations and penta was next on that list; we started in about 1981. From there we moved on to investigate other pesticides that were either lower-use pesticides or thought to contain dioxins of lower toxicity. You can see the pattern that emerged: first 2,4,5-T because of 2,3,7,8-TCDD, then other wide-use compounds like 2,4-D and pentachlorophenol, and so on. Once we confirmed dioxin levels in any one particular compound, some form of limit was set, either by regulation or as a registration requirement of a maximum dioxin content. Consequently, it became necessary for us to maintain an extensive monitoring program to ensure compliance to those standards in the marketplace.

At this point, I might also mention that the analytical program has been supplemented by a formal re-evaluation of these chemicals by Agriculture Canada in concert with our advisers on the federal regulatory process. In fact, one of the first regulatory actions taken by our department on a pesticide containing dioxins, was the suspension of 2,4,5-T for use around the home, in aquatic and recreational areas and on food crops; that was taken in 1970, and the action was based on the presence of TCDD. So administrative efforts to supplement our analytical efforts do go back a long way. Since that time, 2,4-D, pentachlorophenol and MCPA, a herbicide, have all been subjected to re-evaluation. These are at various stages of completion.

Now, I'd like to look at specific compounds as confirmed sources of dioxins, just to recap how they stand in terms of registration.

2,4-T:

As you know this is no longer registered. Manufacture ceased in the early 1980s and registration was not renewed at the end of 1985, as Dr. Boddington alluded to earlier. There was a regulatory standard of 100 ppb of 2,3,7,8-TCDD set in 1979, and our monitoring that followed in the next five years indicated that the products being used in Canada were well below that level, i.e., around 10 ppb.

2,4-D:

Currently, we have a registration requirement that is a maximum of 10 ppb of any one isomer of dioxin. This was set in 1981. The compound was also placed under formal re-evaluation in 1981. Our monitoring from 1981 to 1985 indicates that the levels have dropped to the point now where most samples do not contain any dioxins and the sensitivity level is 1 ppb.

Pentachlorophenol:

As a result of re-evaluation in the late 1970s, eight uses of the compound were suspended in 1980. Our analytical program began at that time and in 1982 we were able to confirm the presence of hexa-, hepta- and octachlorodioxins. We did not find 2,3,7,8-TCDD. Again the sensitivity limit was 1 ppb. We also noted that the dioxin levels in pentachlorophenol have been dropping since we first started to analyze in 1981. Today we have a registration requirement of a maximum of 5 ppm as a typical analysis for hexachlorodibenzo-p-dioxin. We also have a label improvement program on pentachlorophenol which has cleaned up the number of uses and also ensured that all the suspensions throughout 1981 were completed. We succeeded in having manufacturers stop marketing green-coloured penta which was being confused with other wood preservatives. We removed dip uses from our label, hoping by that to reduce release and exposure to pentachlorophenol.

Trichlorophenol:

This is no longer registered. Agriculture Canada considered terminating registration in 1980, but there were residual stocks in Canada. As a result, at the next renewal period for registration in 1985, we informed the registrants that we would not be renewing registration of trichlorophenol or its sodium salt.

MCPA:

A wide-use herbicide, was placed under re-evaluation in 1981. A recent analysis that we completed confirms absence of any mono- or dichloromethyldioxins; again sensitivity is 1 ppb.

Dicamba:

This is another herbicide with much smaller use than 2,4-D or MCPA. Our investigations indicate the presence of low levels of dichlorodibenzo-p-dioxin; that is, under 10 ppb. We have not set a standard as yet: the levels are based on preliminary sampling and analyses. We are confident in the analyses and will now proceed to sample and analyse on a rotational basis.

Our future efforts on dioxin analysis will be conducted using a prioritization scheme. We'll be looking largely at the manufacturing conditions and molecular structures to see if there is a significant likelihood of the presence of dioxins. We'll also be considering the overall re-evaluation priority given to the chemical that contains those dioxins to determine in an orderly manner which compound should be analyzed next.

However, as I alluded to, we're continuing to monitor the Canadian market to ensure that all the standards and requirements are being met. We will be doing about 250 samples of pesticides in 1987-88. We will also be sampling five new compounds for method development but these are getting down to levels where, relative to 2,4-D and pentachlorophenol, they're relatively minor in their significance of dioxin content or at least are suspected to be.

In closing, I would like to mention that in Agriculture Canada we have some recent initiatives with regard to pesticide registration. In an effort to consult a broader audience on some of the more difficult decisions we were faced with on pesticides in general (not necessarily pesticides containing dioxins), and, to promote more informed participation on the regulatory decisions that must be made, we've developed a number of what we call discussion documents on specific pesticides. These documents will present health, environmental and economic considerations, and such a document has been prepared on pentachlorophenol. It's currently in late draft form and we hope to release it in the coming months.* It will propose some reduction in the use pattern of tetra- and pentachlorophenol. It will propose some management options; that is, if we're going to keep the compound, there must be some requirement to improve the handling.

* Released in June 1987 by Agriculture Canada.

As I say, the document will be released in the coming months and I'm quite prepared to share the document with CCREM. We're hopeful of reaching the best-balanced decisions that we can get through this consultative approach.

DIOXIN SOURCES - INDUSTRIAL AND MUNICIPAL EFFLUENTS AND WASTES

Murray Brooksbank
Issue Coordinator, Great Lakes Environment Program
Environment Canada

In the next few minutes, I'd like to provide an overview of wastes, primarily industrial wastes, that have been associated with various kinds of dioxin and furan contamination. As has been mentioned earlier, the main focus was orginally on 2,3,7,8-TCDD, a specific isomer, and the attention there was directed to the production and waste disposal practices of 2,4,5-trichlorophenol, which is the precursor chemical for the herbicide 2,4,5-T.

2,4,5-trichlorophenol was manufactured in two locations in the Great Lakes drainage basin at Midland, Michigan, Saginaw Bay, and on the Niagara frontier, both of which have led to 2,3,7,8-TCDD contamination in the Great Lakes system.

The Niagara frontier has provided perhaps the most concern to Canadian citizens because of the significant influence it has on the water quality of Lake Ontario.

The trichlorophenol was manufactured by Hooker Chemicals and Plastics, which is now known as Occidental Chemical Corporation, during the period 1940 to 1972. It disposed of its waste at a number of locations, the most notable of which are the dumpsites Hyde Park, S Area, Love Canal and 102nd Street. S Area is actually located within the Occidental plant site. There is another Occidental plant, somewhat upriver adjacent to the Grand Island area, which is Occidental Durand's plant at North Tonawanda; I'll refer to it in a minute.

Information on 2,3,7,8-TCDD contamination associated with those sites varies, depending on the level of effort that has been expended. There is TCDD at the Love Canal associated with the drainage system, storm sewers, the creeks that drain the area and the adjacent Niagara River. By far the largest quantity is associated with Hyde Park, which received in the order of almost 3,000 metric tonnes of trichlorophenol "still bottoms" or waste, and this has led to estimates of between .6 and 1.5 metric tonnes of 2,3,7,8-TCDD.

Environmental levels vary substantially. The non-aqueous phase material, which was referred to by an earlier speaker, contains 20 ppm of 2,3,7,8-TCDD and this is the material that is seeping out of these sites; it's also associated with Love Canal, S Area and 102nd Street - dense, viscous, heavier-than-water material that is moving. It's very complex chemically. The Hyde Park material has been rather extensively analyzed but only 40 percent by weight can be accounted for in terms of chemical makeup.

There is contamination in the groundwater that leads to the Niagara River and it's draining into the Niagara River.

The soil at the S Area site was studied by the U.S. Environmental Protection Agency as part of its national dioxin program to look at general contamination of soils in these production facilities. Again the levels are quite high.

All these areas are in litigation and in varying stages of investigation and mediation. Hyde Park and Love Canal both have perimeter drains and they're collecting this non-aqueous phase material, all of which is being stored; there's no available destructive means for this material. On the Niagara frontier presently a few hundred thousand gallons of this material are being stored. There will be a test burn next month at an industrial incinerator on the Occidental plant site. Occidental is attempting to get approval to burn this waste in its incinerator and if it gets that approval, it will be the first commercial facility in the U.S. to burn dioxin waste.

There's also a major study on the Niagara River and Lake Ontario dealing with fisheries, water and sediments. That was arrived at through negotiations between the U.S. Government agencies and Occidental, and they're going to attempt to derive a quantitative loading consideration, which will help derive the remedial activities. They're trying to set an acceptable loading rate of dioxin to the system which will lead to levels in fish that do not constitute a health hazard.

There's very little information on the other congeners associated with waste on the Niagara frontier; that was referred to earlier as well by one of the speakers.

The Pettit Flume sediment; this is information from the Ontario Ministry of the Environment, which conducted a study at Occidental Durand's plant site in North Tonawanda. The Pettit Flume is the drainage area, a sewer, that carries processed waste water from that facility as well as infiltrating groundwater. The infiltrating groundwater is believed to be the primary source of this material because of the previous waste disposal practices on these production sites.

Again, we're in the parts per billion level here now and primarily looking at furans. The tetradioxins do include 2,3,7,8-TCDD which is moving from that site. Caged clams exposed to this effluent did in fact pick up all the congeners of dioxins and furans in varying amounts, primarily in the lower congeners which are more readily bioaccumulated, and they did pick up 2,3,7,8-TCDD so it's a source to the Niagara River. Quantitatively, we have some difficulties assessing how much is actually going into the river. While Canada did not manufacture 2,4,5-trichlorophenol, we did import it at a number of plants in Canada for the production of the herbicide 2,4,5-T. We have some data on soils around a plant at Elmira, Ontario which produced the herbicide 2,4,5-T during the period, I believe, from 1950 to 1963. The wastes were drummed and buried in the ground and there is some indication of some soil contamination. Again you're dealing with orders of magnitude lower than some of the previous information, and you're looking at higher congener profiles in both dioxins and furans. The tetradioxin was not found in the soils, but 2,3,7,8-TCDD has been found in drums excavated from the site.

This work is continuing, the primary concern being the proximity of the aquifer for the cities of Kitchener-Waterloo; the attempt is to discern the extent of any contamination in the ground and potential mobility of that contamination in groundwater.

Just briefly, there was some attention drawn to the so-called Sarnia "blob", which was the material on the bed of the St. Clair River adjacent to the Dow Chemical plant in Sarnia. This material is similar in physical characteristics to the non-aqueous phase material on the Niagara frontier. Again, we find parts per billion in general, or orders of magnitude lower than the kinds of numbers you see on the Niagara frontier associated with the Pettit Flume sediments or certainly the NAPL

The tendency towards the predominance of the higher congeners: neither the 2,3,7,8-TCDD isomers of dioxin or furan that generally are acknowledged as the more toxic forms were evident in this sample.

Considerable attention in Canada was focused on pentachlorophenol and particularly its use in the wood preserving industry. Recently in the last year the two major users in the Province of Ontario -- the Northern Wood Preservers, Thunder Bay Watershed in Lake Superior and Domtar on the Lake Ontario drainage basin -- were looked at; their effluents were analyzed. There were in fact hexa-, hepta- and octodioxins detected in the effluent at parts per trillion levels. The numbers between the two plants were roughly similar. Again, furan levels were low. There was some site contamination, contaminated soils and adjacent lake sediment at the Northern Wood Preservers site. Both of these facilities are being evaluated for alterations to their waste water treatment facilities and, as mentioned by the previous speaker, the product quality of pentachlorophenol has in fact improved as well. So right now it's primarily an assessment process to determine whether these numbers are indeed representative and how extensive site contamination has been.

There are also pulp and paper mill studies in progress. Although 2,3,7,8-TCDD was found in the sludge at one plant on Ontario, a subsequent study at eight other plants didn't find any 2,3,7,8. Some U.S. studies have found a similar kind of situation. The preliminary indications are that they've found low parts per trillion levels in bleached pulp and they've also found contamination in their effluent at parts per quadrillion levels. There was a suggestion that, because of its presence in bleached pulp, the chlorination process might have produced the 2,3,7,8, but this is highly speculative at the present time and the source of that dioxin in pulp and paper processing is basically unknown.

PCB wastes now also contain substantial quantities of tetra-, penta- and hexafurans. It's also known that pyrolysis of PCBs at temperatures lower than 700°, leads to substantial creation of furans and particularly the toxic 2,3,7,8-TCDD isomer. Given the ubiquitous nature of PCB usage and its subsequent release into the environment, it's inevitable that the 2,3,7,8-TCDF levels that we do find in the environment are to a certain extent, and right now an undefinable extent, related to PCB losses to the environment.

Finally, sewage sludge. Sewage plants being the great integrators of human activity, you would expect to find something there and indeed you do. In sewage sludge from Elmira we find the higher congeners, the hepta and octa congeners of dioxins and furans. These numbers are in fact representative of some samples that I've seen from New York State and from Germany. You do, depending on the industrial municipal makeup of the process streams, get variations in the numbers. You do, in some cases, get the hexadioxin formed. So there can be some variability, which you would expect, based on the use of the system.

In conclusion, there are a number of industrial and municipal sources of dioxins and furans. The numbers and quantities that you would expect from these sources are highly variable. A lot of the data that was discussed today is based on relatively little sampling. The representativeness of the data is sometimes in question, but I hope I've provided some sense of what sources are being looked at presently and their contributions to the environment.

DIOXIN EPIDEMIOLOGY AND TOXICOLOGY

Dr. Andrew Gilman
Head, Industrial Chemicals and Product Safety
Environmental Health Directorate
Health and Welfare Canada

By now you are well aware that polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are two chemically related families of chlorinated hydrocarbons. You are also aware that they are produced by a variety of natural and anthropogenic processes and that they occur in the environment as mixtures.

I am about to tell you that there are wide-ranging toxicities for the 210 combined congeners. This information should convince you that assessing the toxic potential of 210 compounds that appear in ever-changing mixtures and concentrations, that can be delivered by air, on particulates, via ingestion of water, food or soil, or through the use of consumer products and that have vastly different individual potencies is grossly understated by the word "complicated".

It's our job, as scientists and regulators and administrators working together, to make that complicated job simple. If we don't succeed, we won't have any credibility with the public on this or any other environmental isue.

I am going to talk about the epidemiology and toxicology of PCDDs and PCDFs. I'll give you a summary first of the sorts of effects that are seen in mammalian systems in general. Some of these are better demonstrated in humans; some are better demonstrated in animals. Then I will give you some specific details on the animal studies, followed by some specific information on the human studies, a little evaluation and some conclusions.

In terms of summary: Animals exposed for long periods to PCDDs and PCDFs develop a wasting syndrome. This involves loss of body weight, general weakness and tiredness. There is also a wide range of skin disorders, including chloracne in humans. This is an acne-form lesion that appears on the face, the back, and sometimes the shoulders and chest. The lesions have small black heads and can be quite disfiguring. Thickening and discolouration of skin and loss of hair also occur in some species. There are organ-specific effects, especially in the thymus and the liver. The thymus tends to be responsible for immune function and it shrinks when there is an exposure to these sorts of chemicals. Thus the immune system may not function normally. The liver tends to respond by being stimulated. Enzymes are turned on, metabolism accelerates and the liver becomes enlarged. Cells may be transformed and in some cases tumors develop in the liver.

The hematological system also undergoes certain changes in some exposures. There are reported effects on reproduction and teratological effects (a teratogen is something that causes a malformation in a developing fetus).

Carcinogenicity has been reported when animals have been exposed for long periods of time; i.e., lifetime exposure.

PCDDs and PCDFs also induce enzymes in many organs. You will often read and hear about enzyme induction in reference to these chemicals. Aryl hydrocarbon hydroxylase is a drug-metabolising enzyme. The degree to which the various PCDD and PCDF congeners turn it on correlates very well with the acute toxicity of these same congeners, so it has been a useful tool for predicting toxicity.

Now, some details on animal toxicology. Acute toxicity is based on single or short-duration exposures. It's important to understand there is a very wide range of effects between species and a wide range in toxicity (see Figure 1).

Figure 1

Acute Toxicity (LD_{50}) in Mammals

° Range: 0.6 - 5051 ug/kg b.w.

° Relative Toxicity: Compared to 2,3,7,8-TCDD

P_5 CDD/F	1 - 0.5
H_6 CDD/F	0.1 - 0.01
H_7 CDD/F	0.01 - 0.001
D_2 CDD/F	0.001 - 0.0001
T_3 CDD/F	0.001 - 0.0001
M_1 CDD/F	0.00001 - 0.0000001
O_8 CDD/F	0.00001 - 0.0000001

If I used acute exposure animal data, assumed that these amounts were toxic for humans, and converted these for a 70-kilogram individual, the number of concentrated drops lethal to humans would range between one thousandth of a drop and seven drops. This gives you some perspective, I think, on the acute toxicity of PCDDs and PCDDFs.

As you add chlorine, beyond the chlorines that appear in the four lateral positions on either side of the molecule, you begin to lose toxicity, as Figure 1 shows. Also if those four lateral positions on the two benzene molecules are not filled, you begin to lose toxicity.

What about the teratogenicity and the reproductive effects associated with exposure to these substances? PCDDs and PCDFs do not appear to be very teratogenic, ~~e.i.~~ i.e., capable of causing permanent developmental abnormalities in offspring. Cleft palate has been reported in mice but not in rats exposed to 2,3,7,8-T_4CDD and T_4CDF. Beyond this, only D_2CDD and H_6CDD have shown some teratogenicity and at higher concentrations than 2,3,7,8-T_4CDD.

PCDDs and PCDFs are capable of causing fetotoxic and embryotoxic effects such as buildups of fluid in pup tissues, aberrant functioning of kidneys, hemorrhage, fetal resorptions and low birth weights in several species, including primates. While it is prudent to consider 2,3,7,8-TCDD and other 2,3,7,8 substituted PCDDs and PCDFs as teratogens, there is little good supportive data. There is a slightly stronger basis for declaring them fetotoxicants.

Both 2,3,7,8-TCDD and H_6CDD cause reproductive anomalies. In a multi-generation study with rats there were reductions in pregnancy incidence, in litter size and birth weights, and neonatal survival. Fertility of offspring was also affected. In Rhesus monkeys a decline in pregnancy rate, an increase in abortion rate and a reduction in male fertility have been reported following chronic exposure to 50 ppt 2,3,7,8-TCDD.

The mutagenic potential of PCDDs and PCDFs is not entirely resolved. It is reasonably clear, however, that 2,3,7,8-T_4CDD does not have great capability to damage chromosomes or cause mutations. This statement is contrary to assessments made by individuals who report upon single positive findings in bacterial culture assays and ignore the overall weight of evidence from all studies.

A great deal of emphasis has been placed on the carcinogenicity of PCDDs and PCDFs. To date congeners from only three PCDD isomeric groups have been tested. 2,3,7,8-T_4CDD caused liver tumors and lymphomas in rats and mice when administered orally. Female rats were the most sensitive and developed excess tumors at 0.01 micrograms per kilogram body weight per day. A mixture of 2,3,7,8-substituted hexachlorodibenzo-p-dioxins was also carcinogenic to mice and female rats. 2,7-D_2CDD was not carcinogenic to rats and studies in mice were inconclusive.

Now on to humans. There is no doubt that PCDDs and PCDFs are extremely toxic substances for humans. However, exposures to date have not lead to an excess of dramatic permanent effects. Best known and best studied has been the Seveso accident in Italy, where a trichlorophenol reactor vessel overheated and exploded, causing a wide range of congeners, including 2,3,7,8-T_4CDD, to descend as a plume down-wind of the manufacturing plant. Years after the accident the major effects were summarized into four categories. Dermatological effects such as chloracne, skin discolouration and thickening of the eyelids confirmed that human exposures had occurred. Moderate effects were reported in the liver, the pancreas, and the respiratory, urinary and cardiovascular systems. Metabolic changes were observed. Finally, neurological effects were reported including mild loss of some senses, general weakness, tiredness, impotence and loss of libido. Immunotoxic effects were not reported in a study of 48 exposed children even though 24 had developed chloracne.

Chloracne has been the most consistent finding in persons exposed to large amounts of PCDDs and PCDFs. This condition can last for several years. Of 193 persons who developed chloracne following exposure in Seveso in 1977, approximately 10% still had chloracne seven years later.

Of major concern to scientists and the public is the question of whether exposure to PCDDs and PCDFs can lead to premature death or cause adverse reproductive effects. To date no study has clearly established a link between such a human exposure and a fatality. The Seveso incident did not lead to excess mortality and has not yet lead to any increase in cancer. However, the latency period has been short.

An accident in 1949 in a trichlorophenol manufacturing plant exposed approximately 250 workers and lead to the development of chloracne in half of those exposed. Thirty years later, 32 workers in this group or cohort had died with no apparent increase in deaths due to malignant neoplasms. This was fewer than the 46 deaths expected in this group.

A recently completed study of 2,192 PCDD/PCDF exposed chemical workers found no excess mortality (370 vs 396) and no excess numbers of neoplasms. A special analysis of approximately 15% of these workers who developed chloracne lead to a similar finding (33 observed vs 39.5 expected deaths, 6 observed vs 8.9 expected cancers).

Six other studies, most with small exposed cohorts, have reported no obvious excess in cancer or mortality following latency periods of 10 to 28 years. Three studies have reported excesses in stomach cancers and lymphomas, but they were associated with exposure to a wide range of chlorinated organic chemicals. Because of the ambiguities in exposure concentration and period and because of the small cohort sizes these studies cannot be used to prove or disprove the carcinogenicity for humans of PCDDs and PCDFs.

Effects on reproduction have been claimed in connection with exposures following the Seveso accident, the use of Agent Orange in Vietnam and the use of 2,4,5-T. The reports of reproductive failure and birth defects remain unsubstantiated at the present time. Exposure of hundreds of Japanese in Yusho, Japan, to rice oil contaminated with PCB and PCDF did lead to extensive chloracne and other dermatological events and to low birth weight babies. These babies recovered to normal weight by the end of their first year of life. Recent estimates from a Task Group for the World Health Organization are that the victims consumed 0.01 - 0.05 micrograms per kilogram body weight per day of the 2,3,7,8-substituted PCDFs.

While the claims of effects on reproduction are largely unsubstantiated, I think there is a trend in the data from animals and humans which says we should be extremely cautious about reproductive outcomes.

Let's turn to evaluation. What do you do with human data that's inconclusive? What do you do with animal data to try to extrapolate from animals to man, especially when you're dealing with rodents -- and none of us want to be considered rats.

We have a tremendous difficulty in estimating the exposures in the human studies. There just wasn't data in 1945, in 1949, in 1952 to tell us how much people were exposed to. So we can't use that information very readily to determine what are "dangerous" or "safe" exposure concentrations.

The animal data, I think, is reasonably conclusive for 2,3,7,8-tetrachlorodibenzodioxin. There's marginal information for the hexachlorodibenzodioxin substituted in 2,3,7,8 positions and there really is very little long-term data for any other compound.

For evaluation purposes, we can use the reproduction study in rats which went over three successive generations and we probably can use the carcinogenicity bioassays which involved lifetime exposures of rats. And if we take the concentration that caused no observable adverse effect in terms of tumors or adverse reproductive outcome, we could use one nanogram per kilogram body weight per day.

There are two ways then of making this information from animals applicable to humans. We can apply uncertainty factors. These are factors arbitrarily assigned using the best scientific judgement possible, that are applied to the no-observed-adverse-effect-level (NOAEL) in animals to produce a lower concentration that is likely to be safe for humans. The sort of uncertainty factors that would be taken into account here would look after differences in sensitivity between rodents and humans, sensitivity within the human species, and the fact that reproductive effects and tumors are reasonably significant outcomes.

The alternate method is doing a risk estimation, which is a mathematical extrapolation using various models -- in Canada, we are currently using the Robust Linear Model -- and setting some sort of an exposure for humans that is based on a very low risk, perhaps a 10^{-5} risk. A 10^{-5} risk is equivalent to one excess cancer over background per 100,000 people exposed.

In conclusion, the 2,3,7,8 substituted PCDDs and PCDFs are highly toxic to animals and we should consider that they are highly toxic to humans.

We should consider that they are probable human carcinogens, based on the animal data and inconclusive data in humans. We must err on the side of being conservative.

We should assume that they are probably going to have adverse effects on reproduction and we should be satisfied that they do cause reversible toxic effects, although some of those reversible effects such as chloracne are truly prolonged in nature.

We should ensure that human exposures be kept as low as possible. We don't want PCDDs and PCDFs around and we should reduce our exposure to them. Based on the one nanogram per kilogram body weight number we obtained from animals and using risk estimations or uncertainty factors, human exposure should not exceed 2 to 10 picograms per kilogram body weight per day.

How you will choose to ensure that this daily exposure is not exceeded is what Brendan Birmingham will discuss next.

REGULATORY REVIEW

Dr. Brendan Birmingham
Standards Coordinator
Hazardous Contaminants Coordination Branch
Ontario Ministry of the Environment

You just heard the excellent contributions of the previous speakers on the diversities of the different types of dioxins and furans, the problems encountered with analyzing them, the levels in man, pesticides, industrial and municipal wastes, food, combustion sources and the environment and, most recently, toxicology. Well, it's confusing, isn't it?

It's clear that these chemicals can accumulate in fish, birds, sediment, soils, get transported around the environment on ~~flying~~ particles in the air and form suspended particles in the water. Canadians are exposed to these chemicals through a number of pathways: in food, air, water, soil and consumer products. We need to take all these factors into account when developing regulations to control our exposure to these chemicals.

In response to these sorts of concerns, Ontario established the branch that I work for, the Hazardous Contaminants Coordination Branch, in 1982. One of its mandates was to coordinate the development of ~~a~~ multi-media environmental standards ~~study~~, which is a departure from the traditional approach where single-media, air or water or food standards are usually developed by independent groups.

I'm basically going to stay with the Ontario experience for most of my discussion.

The statutory process, as perceived by the Hazardous Contaminants Coordination Branch, is part of an overall strategy for controlling waste that involves four stages.

The first stage is risk identification, where we use preliminary information on toxicology and exposure potential to set the order of priority for proceeding with setting standards. That stage is obviously long past in the case of dioxins and furans.

The next stage of the process is risk analysis, where we review all the scientific criteria, based on what's been found in the literature, and we look at the toxic effects and dose-response relationships. In addition we look at the exposure potential, based on what we found out about levels in the various environmental sources.

We examine all environmental media and receptors to find the most sensitive receptor involved, and in the case of dioxins and furans so far we've been focusing on the human receptor. However, that doesn't mean to say if we got an appropriate environmental receptor that we wouldn't focus on that. At the end of the risk analysis phase, we can derive some sort of acceptable level of exposure or intake. And, in terms of this phase of the process, scientific reviews of dioxins and furans ~~documents~~ have been produced by Ontario, Quebec and the federal government to address some of these aspects of scientific review of dioxins.

The third stage we call the risk assessment phase; at this point we take all the science and start pulling out a rationale for setting levels. We also start taking into account socio-economic and technical factors for standard-setting.

A major decision in this phase is how to allocate the level of exposure amongst ~~into~~ the various routes of exposure. And also in this phase, we might consult with the public about how they feel about our approach to the risk assessment.

The final stage is managing the risk once we set our standards: that means implementing and enforcing these standards.

I'm going to concentrate mainly on the second and third phases, risk assessment and ~~phase 3, risk assessment.~~ risk management.

Ontario has had some experience in developing single-media guidelines and regulations for dioxins and furans. For example, in 1981 we adopted ~~a~~ the federal ~~Small Fish Consumption Guideline~~ guideline for sport fish consumption. In 1983, Ontario drew up the first North American ~~G~~guidelines for ~~D~~dioxins and ~~F~~furans in ~~A~~ambient ~~A~~air. We released our Scientific Criteria ~~d~~Document in 1985. And in 1986, Ontario developed ~~I~~interim ~~D~~drinking ~~W~~water ~~G~~guidelines. These guidelines were developed in conjunction with Health and Welfare Canada and utilized the multi-media approach and the toxic equivalent scheme outlined in the Ontario Scientific Criteria document.

If you are going to make a regulatory decision, you need a consistent basis for proceeding. I'm going to go over what we've done using what was developed in the ~~Green Book~~ Scientific Criteria Document; and I don't want to give the impression that Ontario was entirely alone in this. We've had very good relations and dialogue and consultation with Health and Welfare Canada and with Environment Canada.

Let me describe the risk analysis approach that we took in our ~~documents~~ Scientific Criteria Document. There are two parallel kinds of processes going on during the evaluation. One is the evaluation of the toxicology; we use that as the basis for calculating an acceptable level of intake using the types of approach that Andy Gilman just described. This gives us an umbrella maximum allowable daily intake for all dioxins and furans from all sources that would ensure adequate protection of health, given a lifetime exposure.

The other side of the evaluation includes a review of environmental levels and exposure pathways.

When we get to the end of both those parallel processes, we can compare our calculated intake level with the level of exposure. If the level of exposure exceeds what we think it should be, we have to figure out how much control is required.

There are two major problems associated with developing regulations for dioxins and furans. The first I'm going to call the "mixture" problem, to which everyone else has been alluding; this is related to all the different types of dioxins and furans and also the range of different toxicities found. The type of media that we're all exposed to does contain mixtures, so we can't ignore the mixture problem; we can't just, say, focus only on the 2,3,7,8-TCDD because often it occurs with the others. The problem really arises because most of our toxicological information is based on the 2,3,7,8-TCDD, and we have to figure out some way of taking a mixture and converting it into something we can relate to.

A resolution of this problem was to develop a system of toxic equivalents. That way you can mathematically take the analyzed levels, multiply them by a factor and turn them all into something that we can relate to 2,3,7,8-TCDD. The Ontario maximum allowable daily intake is formulated in terms of toxic equivalents.

The scheme that we developed is now based on the assumption that we only have enough analytical data to tell us the total congener content for each chlorination group. As the analytical technology advances and we have more and more information on specific isomers and we discriminate more finely between the toxic and non-toxic ones, more detailed toxic equivalent schemes are going to be developed. In fact, we have one that's been developed recently by Dr. Grant of Health and Welfare Canada.

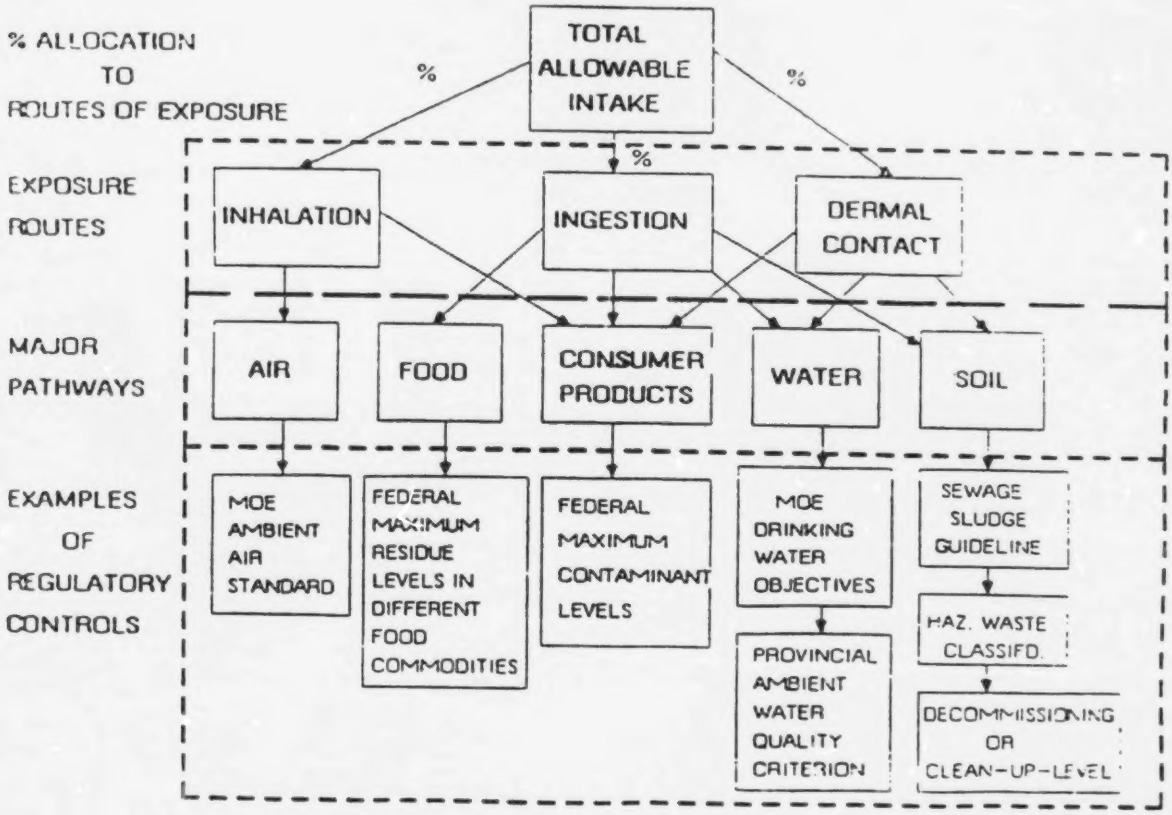
The other major problem in regulating these substances I'm going to call the "ubiquity" problem. As the other speakers have very adequately shown, thousands of dioxins and furans ~~furans~~ are found in all environmental media and there are multiple routes of human exposure: inhalation, ingestion and contact through the skin.

A major decision when you're setting standards, from a multi-media point of view, is how do we take our total allowable intake and break that up into the various routes of exposure? ~~And then,~~ Subsequently, how do we develop regulations for each of the media associated with each of the major pathways?

~~Table~~ Figure 1 gives you an idea of the next stage after breaking it down through the major ~~pathways~~ exposure routes into the major ~~groups~~ exposure pathways that we can regulate and gives you examples of the type of regulations one can develop. These expo-

~~TABLE~~ FIGURE 1

DEVELOPING REGULATORY CONTROL LEVELS


% ALLOCATION TO ROUTES OF EXPOSURE
TOTAL ALLOWABLE INTAKE
%
%
%
EXPOSURE ROUTES
INHALATION
INGESTION
DERMAL CONTACT
MAJOR PATHWAYS
AIR
FOOD
CONSUMER PRODUCTS
WATER
SOIL
EXAMPLES OF REGULATORY CONTROLS
MOE AMBIENT AIR STANDARD
FEDERAL MAXIMUM RESIDUE LEVELS IN DIFFERENT FOOD COMMODITIES
FEDERAL MAXIMUM CONTAMINANT LEVELS
MOE DRINKING WATER OBJECTIVES
PROVINCIAL AMBIENT WATER QUALITY CRITERION
SEWAGE SLUDGE GUIDELINE
HAZ. WASTE CLASSIFD.
DECOMMISSIONING OR CLEAN-UP-LEVEL

sure measurements consider the amounts of TCDD and the equivalent amounts of other dioxins and furans that might be inhaled, ingested or absorbed through the skin.

Ontario ~~has been~~ went through this sort of exercise when we developed the ~~Green Book~~ Scientific Criteria Document., but it became clear that there are multiple agencies involved: national agencies, international agencies and provincial jurisdictions are all involved in the control of dioxins from the various sources. There are obviously advantages to be gained from collaborating in the development of uniform national objectives.

From a Canadian perspective, the major step in this direction was the establishment of a Federal/Ontario Working Group to develop national multi-media environmental standards. This group has used Ontario's Scientific Criteria document to allocate the ADI, and used this as a basis for developing national environmental standards.

The first phase of the work was to just look at multi-media standards per se. We developed a document that has several recommendations or guiding principles for developing multi-media standards. I'll just go through some of ~~those~~ these principles.

The basic assumption is that if you're going to apply multi-media guidelines, the starting point will have to be an umbrella acceptable intake number. When evaluating such a number, we want to see what toxic endpoints are associated with each of the major exposure ~~groups~~ routes. What are the relative contributions of the exposure pathways? Are there special sub-populations which we should be paying attention to since they may be exposed to different amounts because of their age, sex, ethnic background, socio-economic status or location?

We should also consider exposures to mixtures of chemicals that may lead to interactions that increase the risk posed by a chemical. ~~And~~ In the case of the dioxins and furans, we have developed a toxic equivalent scheme to handle this sort of problem.

The guiding principles also indicate socio-economic considerations affecting the allocation of the intake ~~in one~~ amongst of the pathways. For instance, economic and technical feasibility of control of the various sources indicates we should take into account which pathway is more amenable to control. When we're looking at incineration sources, for example, obviously governments can move to control municipal and industrial sources a lot more easily than they can handle some of the other sources, such as forest fires.

Another economic consideration that should be taken into account in setting guidelines is what are the current analytical detection limits. We may end up having to set standards below the current limits. Normally we don't want to get involved in this but if we face a food chain magnification effect or if we have a known source but can't detect the contaminants in the ambient air or soil near the source, we may have to set a number below what we can measure.

There are several benefits to the multi-media approach: these mainly include the fact that we consider total exposure and keep it below a maximum allowable intake level, that risk evaluations and decisions are consistent and that by combining our efforts into a single comprehensive scientific evaluation, we take advantage of the best technical advice available and avoid duplication of effort.

To conclude, a major decision in the standard-setting process is the allocation of the level of exposure ~~among~~ amongst the various routes of exposure. The multi-media approach in standard-setting confers several benefits: by taking a consistent approach to risk evaluation, by considering total exposures, and by avoiding duplication of effort. Such an approach may involve multi-agency participation and can be labour-intensive. Though it is difficult to arrange because of organizational obstacles, reorganization of regulatory agencies is not necessary. The approach requires coordination and involvement of a multi-disciplinary team of experts, which has been achieved by the Federal/Ontario Working Group.

It may take longer to develop standards this way but it provides a uniform basis for the protection of the public and the environment. Today we have a multi-disciplinary team of experts assembled and I hope we will be able to help you move forward in making decisions on how to control these substances.

SECTION 2

SECOND PLENARY SESSION - WORKSHOP REPORTS

CONTROL TECHNOLOGY WORKSHOP REPORT

Ron Gott - Facilitator
Raynald Brulotte and Walter Giles - Rapporteurs

Summary

Raynald Brulotte. At our Control Technology Workshop, we first identified the potential sources of dioxins. The main categories are combustion or incineration, chemical sources, and historical sources.

Combustion or Incineration Sources

Within the combustion category the order of priority is municipal waste, hazardous waste, biomedical waste, wire reclamation, and sewage sludge. It appears that for these five control options are readily available.

More information is needed about the remaining combustion sources, which include combustion of kraft paper mills sludges or by-products of motor vehicle emissions, black liquor recovery boilers and blast furnaces. We have also included the aluminum smelter and ferro-alloy industry, because those processes use lots of coke, which contains very low concentrations of chlorine~~,~~ which is essential in the formation of dioxins.

Chemical Sources

Turning to chemical sources, we identified ~~P~~pentachlorophenol use in wood preservation as the prime concern. Next came sewage treatment plant effluents, including the use of chlorine as a disinfectant. Our third and priority was sewage treatment plant aerosols and fourth other halogenated organics, like the organo-brominated compounds.

Landfill is also a relatively important chemical source. Our last two members of this category are 2,4-D formulation and 2,4-D use.

We need more information for the first five members of this category.

Historic Sources

For the historical sources, the first priority is in-use treated wood, followed by PCBs and abandoned industrial sites, and finally dredge material. And we need more information for all the sources except PCBs.

Controls

For the sources where control is proposed, we have to identify options, identify what work is already underway and assess the ramifications of it before making any recommendations or proposing actions for implementation. Where further information is required, we must determine the type of information needed and the purpose of the information, before making any recommendations.

For cases where control options are applicable -- municipal waste, hazardous waste, biomedical and sewage sludge -- programs should be developed to complement those already in place. Current technology must be assessed so that existing facilities can be upgraded and eventually meet the same criteria as new facilities.

CCREM should continue its current program supporting the efforts of individual control agencies. CCREM should also become more involved in the coordination of efforts to deal with biomedical waste.

Information Needs

For the cases where more information is required, we must determine first whether the potential source really presents a problem.

In the case of pulp and paper mills, for example, we have to make a survey of current practices. We have to characterize the sludge and the ash to see if any other things are present before going to the more expensive stack assembly. We should try to do this work as a joint project with industry.

For blast furnaces and similar operations, we should first sample the ashes from the electrostatic precipitator to analyze for the presence of any dioxins. We should also try to cooperate with the U.S. EPA, which is doing similar work.

Motor vehicles are an inter-provincial and national issue, of course. The information required is the emissions for leaded and unleaded gasoline used in cars with and without catalytic convertors. We should also have some information on fuel additives and we should sample the exhaust solid residue to detect the presence of dioxins.

As for wire reclamation, this is a general area where some monitoring is required. The options are known but the consequences are not.

Detailed Considerations (Chemical Sources)

Walter Giles. Under chemical sources there were three that we thought we might be able to do something about right away: 2,4-D in use, 2,4-D in formulation, and PCBs. For all the rest we thought we needed more information.

(a) 2,4-D

Regarding 2,4-D use, there already is improved product purity as a result of recent actions taken by Agriculture Canada. The department is currently reviewing 2,4-D and Ontario has completed its review and, as a result, has indicated that continued use of 2,4-D will certainly be permitted in Ontario for this year at least.

Assuming this continued use, we feel that control over the product should be tightened by such means as better labelling and increased public education.

We also need some monitoring to identify sloppy usage. This will have a limited economic impact on the applicator and will have some resource costs for the regulators, e.g., increased staff to do the monitoring during the application season. However, there will be long-term benefits because it will be part of a general upgrading of the application of pesticides and herbicides. Whatever we develop here can be carried on into other applications as well.

CCREM members should proceed with the implementation of the above proposals share experience and information.

On 2,4-D formulation, we simply point out that the federal government ought to consider characterizing any problems in the formulation and distribution and then develop controls and a code of good practice. Educational and monitoring activities similar to those mentioned for 2,4-D use are also recommended.

(b) PCBs

With reference to PCB controls, we simply remind people that CCREM has a PCB action plan and we should get on with it. CCREM also has a hazardous waste action plan, a component of which deals with emissions that are involved in PCB destruction; we should get on with that too. The means of doing that is to develop and implement incineration standards. There will be a significant economic impact in this but, nevertheless, it's something that we really must do.

(c) Wood Protection/Preservation

There are a number of areas for which we thought we didn't have sufficient information. The first is the use of PCPs in the wood protection field. We've made a distinction between wood protection and wood preservation plants because we think they're slightly different in terms of what you might control.

In the wood protection field, particularly in British Columbia, a code has been developed and is now being applied to the application of preservatives in such places as sawmills. A national code is being developed.

In terms of information required, we still need to investigate the impact of treatment plants and storage practices on environmental and health effects in order to develop a basis for control practices. CCREM should ensure we all implement the programs outlined above, even though this could be expensive.

As far as wood preservation plants are concerned, again a national code is necessary. We don't need any more information. We can develop a national code with what we know and CCREM should ensure that the provinces implement the code when it becomes available.

In terms of follow-up action, we must inform industry of the requirements, tell the public about the actions that we've taken, and conduct knowledge transfer seminars. Then we'll have to audit and take regulatory action, as required.

(d) Halogenated Aromatics

We need to investigate the significance of halogenated organics throughout their life cycle to find the problems: Environment Canada should take a lead role.

Historic Sources

Another category we noted is abandoned plant sites and dredgates. Both require similar action. They're site-specific, so we first have to find out where they are, then determine the environmental impacts of each case. After the problem is characterized, possible solutions must be identified and reported, for implementation by the appropriate agency. Here we see a role for both the federal and provincial governments in conducting these studies.

Others

Three other categories were identified by our group. First, there is a lot of treated wood in-use around the country, which may. We need to investigate the significance of any impacts. We see both a federal and provincial role in determining the extent and nature of the problem. Control programs should be developed, if required. This will not be easy because of the many uses to which treated wood has been put and potential for problems developing in a variety of ways: the impact on the aquatic environment; the land; or animals in barns. This is one of the sources of dioxins in food.

With respect to sewage treatment plants, we need a mass balance analysis of what goes in and comes out of the plants and the form of the release. We need to understand the significance of the impact of each one of these emissions. We then obviously have to improve operational controls for the points of emission at various stages in the treatment plant activity.

Sludge management is an area that clearly needs attention, and obviously proper chlorination practices have to be developed, if they're not now satisfactory. Under Ontario's Municipal Industrial Strategy for

Abatement Program and Hamilton's "Metro Sludge" study, we think we might determine the adequacy of our information for the development of controls. Sharing information amongst the CCREM members will help this process.

We recognize that there are profferation of landfills around the country where each of us is undoubtedly going to have to determine the significance of any leachate or aerial emissions, through evaporation or burning. The purpose, obviously, is to characterize and determine the extent of the problem through the CCREM Research Coordination Committee which should develop the terms of reference and a study plan to achieve this goal.

SUMMARY OF CONTROL TECHNOLOGY WORKSHOP OBSERVATIONS

1. Control of 2,4-D should include:
    - better labelling;
    - more public education;
    - monitoring for sloppy manufacture and usage;
    - sharing of data with all CCREM members; and
    - assessment of and for improved manufacturing practices.
2. Control of PCB should include:
    - implementation of PCB action plan; and
    - development of incineration standards.
3. National codes under development for wood protection activities and wood preservation plants - they should be finalized, adopted by the provinces, and communicated to the industry and the public.
4. Where information on sources is needed, CCREM should characterize and determine the extent of the problem through monitoring and analysis, develop control options, and recommend solutions to the appropriate authority.
5. More information needed on the following dioxin sources:
    - kraft paper mills;
    - motor vehicle emissions;
    - black liqueur recovery boilers;
    - blast furnaces;
    - PCP in wood protection;
    - treatment plant effluent;
    - sewage treatment plant aerosols;
    - other halogenated organics;

- landfill;
- PCP treated wood in-use;
- abandoned industrial sites; and
- dredged material.

STANDARDS WORKSHOP REPORT

Ivy Wile - Facilitator
Victor Shantora - Rapporteur

Lack of Standards

The first problem area relates to the lack of standards. We simply don't have any standards for many of the exposure pathways. Where standards do exist, (e.g., Ontario's provisional air guideline) they are based on the assumption that man is not exposed to other sources of dioxins and furans.

National ambient standards or guidelines should be developed for the major exposure pathways (air, soil, water, food), for the protection of human health. Note that we use the term "standard" generically, they could be guidelines, codes or whatever.

A multi-media approach should be used to develop these standards, (to ensure that human exposure through all pathways does not exceed an overall allowable intake). The levels should be set on a national basis; at least the upper limits should be based on average adults or average sectors of the population. Then, based on these minimal national requirements, provinces can refine the standards for site-specific considerations or for critical sub-groups: natives that consume a lot of fish, pregnant females or infants, for example.

Clearly, these standards or guidelines must not be seen as licences to pollute up to that level: they're really benchmarks to ratchet down to, not up to.

An associated problem is that many of the basic exposure parameters used in the development of standards are inconsistent from jurisdiction to jurisdiction. For example some standards are based on a 60 kg adult, others on a 70 kg adult. It is recommended that uniform parameters such as body weight of the average adult, amount of food or drinking water consumed per day, etc., be adopted across Canada.

Another problem area concerns the fact that dioxins and furans occur as mixtures in the environment. To determine the total toxicity of these mixtures, some scheme for toxic equivalent factors (TEFs) is required. TEFs are used to mathematically convert measured levels of other dioxins and furans to a number which gives us an estimate of the toxicity of the mixture in terms of the most toxic one, e.g., 2,3,7,8-TCDD. It is recommended that a single TEF system be adapted across Canada to provide a uniform measure of the total toxicity of a mixture. Furthermore, efforts should be made to develop an international system of TEFs.*

Compliance Monitoring

The second problem area concerns monitoring. There is a lack of analytical capability across the country to monitor for compliance with any standards that we may have. We also lack confidence in some of the data that is being developed.

We encourage the development of regional laboratories that have the analytical capability for dioxins and furans. We also recommend that national protocols be developed for quality assurance and control, sampling, analytical methods, and field sampling. We will then have a common basis for interpreting our results and have confidence in the quality of dioxin analyses right across the country.

Due to the high costs involved in developing appropriate laboratories, it would be more cost-effective to establish regional labora-

* International agreement on a single TEF scheme has been reached.

tories in key areas first, rather than establishing a laboratory in each province. In addition as a cost reduction measure, monitoring activity should be problem oriented, focusing on areas of concern.

Other Needs

Regarding other research priorities, we feel that there's a need to develop biological testing systems. We need to establish and determine the significance of the body burdens of dioxins and furans in humans or other biota. A reasonably comprehensive database is only available for 2,3,7,8-TCDD. Data on other dioxins and furans is limited. More toxicological data is needed to refine our TEFs and to improve our understanding of the health significance of mixtures.

Networking is another key aspect of the standards issue. At the moment experts probably don't get as many opportunities as they could or should, to talk to each other. People spend a lot of time generating data but the information just isn't getting out to the people who need it. Development of a comprehensive data base is costly and time consuming.

It is suggested that CCREM establish a coordinating mechanism for planning of work, for project-sharing of data and for providing some Canadian perspective or overview on what information exists. There are still many data gaps, and networking will help to fill those gaps.

Regarding communications, the problem is that inconsistent, contradictory information on dioxins is often released to the media and the public. Furthermore, we are not taking advantage of some opportunities for passing along good news, such as declining trend for dioxins in fish. If you don't take credit for your own actions, nobody else will.

Conclusions

Some general conclusions: first, it's time to mount a fairly major initiative to prepare a "state-of-the-environment" report on dioxins - everything we know, put under one cover, to provide some perspective on the issue.

The key spokespersons in the various areas of expertise should be identified so that good information goes out to the people that need it. This assures that information is timely; that it's factual and that we're not contradicting ourselves. We need to establish a dioxin-specific mailing list within government and perhaps also outside government. The mechanism could be through CCREM, and it certainly should be through each agency that's doing any work on dioxins.

Another thing that would help us to avoid surprises between the various jurisdictions is, wherever possible, to give each other advance notification of any impending actions: the release of a report or health advisories, for example. This would ensure that we keep the stories straight and consistent.

We should consider the use of seminars and workshops for public education purposes or for educating specific target audiences.

Since we're grappling with a very big issue, and considering the amount of money being spent on dioxins, it would be advisable and timely to spend a little bit of money on professional advice, in terms of how to communicate the information we generate to the public.

SUMMARY OF STANDARDS WORKSHOP OBSERVATIONS

1. National ambient standards (guidelines, codes) should be developed using a multi-media approach.
2. Regional laboratories capable of analysing dioxins are needed.
3. National protocols for analytical procedures would provide a consistent, reliable data base.
4. A standardized system of toxic equivalent factors should be developed.*
5. CCREM should establish coordinatory mechanisms for sharing data and providing a national perspective on many issues.
6. There is a need to develop biological testing systems.
7. Communication should emphasize the good news; could be done through a "state of the environment" report.
8. Release of information should be better coordinated, with advance notification to other scientists, delegation of spokespeople, and a dioxin-specific mailing list maintained by CCREM.
9. Professional communication advice and possible use of seminars, information strategies should be considered.

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* An international agreement on a single TEF scheme has been reached.

REGIONAL ISSUES WORKSHOP REPORT

Dr. John E. H. Ward - Facilitator
Simone Godin - Rapporteur

The workshop on regional dioxin issues was based on discussion of the following major topics:

- sources, exposure and impacts
- analytical chemistry resources
- communications
- control technologies
- standards, laws and regulations
- economic factors

Most of the workshop was spent discussing each of these items in turn, with the last two hours spent reviewing the gaps in PCDD and PCDF data and capabilities, and compiling a set of observations and conclusions.

Sources Exposure and Impacts

The most important finding during discussions about regional aspects of sources, exposures and impacts of PCDDs and PCDFs was that, with exception of Ontario, most provinces do not have a clear idea of the specific sources, typical ambient levels and human and/or environmental impacts of these chemicals. More simply put, most provinces do not know if they have a dioxin problem.

As a result, there were many more questions than answers. For example, some participants wondered about the significance of the following potential sources of PCDDs and PCDFs: low temperature combustion of wood contaminated with chlorophenols, black liquor boilers in pulp mills, and wire reclamation incinerators. Others had unanswered questions about the importance of several potential industrial dioxin sources such as former wood treatment and pesticide formulation operations, pulp and paper mill effluent discharges, and steel mills. Possible exposure to PCDDs and PCDFs through municipal sources such as open burning of refuse, refuse incinerators, sewage treatment effluents and sewage sludge incinerators also received some attention.

Analytical Chemistry Resources

The general inability of the workshop to answer these sorts of questions in large part seemed to stem first, from an obvious lack of human, environmental and source monitoring data, and second, from the lack of tools to decide what data and impacts are significant. Usually provincial representatives reported their governments neither had the resources to carry out chemical analyses for PCDDs and PCDFs, nor had adequate access to proper analytical facilities in Canada.

The workshop considered several options for improving the situation. In particular, it was noted that cheaper, faster methods for PCDD and PCDF analyses, rapid screening methods, and good quality assurance and quality control programs are needed.

Communications

A number of interesting points emerged during the discussion of communications strategies for PCDDs and PCDFs. One important observation was that the positive aspects of Canada's dioxin programs could be communicated more effectively.

The group also observed that in the context of a communications strategy, PCDDs and PCDFs could often be addresse~~s~~d as part of a larger issue, such as wood preservation or municipal solid waste incineration, and that it is not always necessary, or desirable, to deal with PCDDs and PCDFs separately.

Finally, methods of providing better communications with the public and within the scientific and technical community were considered. This point, in part, arose because some participants felt their jurisdictions lacked good PCDD and PCDF expertise and wished to have better access to dioxin information resources.

Control Technologies

Methods of controlling PCDDs and PCDFs, through source controls and waste management methods were briefly addressed. The suggestion was made, for example, that wast management technologies could be developed and used on a regional or National basis, rather than province-by-province. However, it was soon realised that the Control Technology Workshop and the CCREM Hazardous Waste Action Plan were already addressing this issue adequately, and that the Regional Issues Workshop need not consider it further.

Standards, Laws and Regulations

In this section, the National effort to establish multi-media standards for PCDDs and PCDFs was acknowledged. One question about this approach concerned the need for regional allocation of an acceptable daily intake for PCDDs and PCDFs, depending on the relative importance of different exposure pathways. For example, while one province may have low emissions of PCDDs and PCDFs, another may have many sources that contribute to relatively higher levels of dioxins in air. One proposal to deal with this problem of regional differences was to place a National cap on the allowable intake for any particular exposure pathway.

Economic Factors

The subject of economic factors did not receive much attention in the workshop. This arose, in part, because little is known about the impacts of PCDDs and PCDFs in most provinces. Without knowledge of human and environmental impacts, any economic impacts must also be unknown. ~~must also be unknown.~~ The cost of keeping government scientists and technologists up-to-date on PCDDs and PCDFs was considered to be minimal.

Observations and Conclusions

1. A permanent Dioxin Working Group reporting to the CCREM Toxic Substances Steering Committee needs to be created. It was suggested that representatives from each province participate.

   With so many unanswered questions about sources, exposures, and impacts, the workshop strongly indicated that a mechanism to identify, set priorities, and make recommendations about these issues is badly needed. It was agreed that a Dioxin Working Group, which included persons from each province knowledgeable about PCDDs and PCDFs, would be able to assess the situation from a National perspective.

2. The immediate priorities of this Working Group would be to:

   - recommend options for assessing whether or not provinces have a dioxin problem, by addressing point and non-point sources, ambient levels and impacts; and
   - identify regional analytical chemistry deficiencies for PCDDs and PCDFs and recommend remedial options.

   From the standpoint of the Regional Issues Workshop, the primary question seemed to be whether or not a province has a PCDD and PCDF problem. A key part of answering this question, with its considerable costs, is dioxin monitoring, which should be planned so the most important potential sources, exposures and impacts are addressed first. A group of experts with knowledge of the dioxin situation across Canada seemed a sensible vehicle to recommend priorities for such a program.

During the workshop, the discussion focussed from time to time on options for "have not" provinces gaining access to analytical resources for PCDDs and PCDFs. Whether the Canadian public and/or private sectors should take on more of this responsibility, and whether each province should establish PCDD and PCDF analytical facilities, were two questions that were felt would better be considered by a Dioxin Working Group. Participants emphasized the need for good quality control, and to develop less costly, faster analytical methods, including rapid screening techniques.

3. All provinces need access to scientific and technical expertise in PCDD and PCDF issues.

   Many of the provincial representatives reported their governments lacked dioxin expertise, and it was suggested that a Dioxin Working Group could also serve as a National information sharing network.

4. The positive side of the PCDD and PCDF story in Canada has not been adequately communicated, and needs to be emphasized.

5. PCDD and PCDF issues need to be communicated in a consistent manner, in the context of larger issues.

While the last three observations were not given as high a priority as the first three, the workshop nevertheless indicated they should be communicated to the plenary session.

Participants felt that the "good news" stories about dioxins were not receiving enough attention. For instance, the success in controlling PCDD and PCDF levels in certain commercial products, the declining levels of dioxins in the Great Lakes, and the high claibre of the dioxin analytical laboratories that do exist in Canada, should be communicated to the public when the opportunity exists.

It was also thought that dioxins need not always be emphasized as a single theme. Some of the workshop members said that discussing PCDDs and PCDFs in the context of a different issue such as municipal waste incineration, contaminants in pulp mill effluents or wood preservatives would place PCDDs and PCDFs in a broader, more suitable context.

SUMMARY OF REGIONAL ISSUES WORKSHOP OBSERVATIONS

1. A permanent Dioxin Working Group reporting to the Toxic Substances Steering Committee should be established.
2. The Working Group should have representation from all provinces.
3. Its priorities should be:
   - help provinces assess whether they have a problem
   - identify analytical chemistry deficiencies and options for resolving them
   - work towards quality control and efficient, low-cost detection methods
4. All provinces need access to technical expertise.
5. The fact sheets should be publicized through a news release.
6. The positive side of the dioxin story in Canada should be emphasized.
7. Dioxins should be dealt with in the context of larger issues, such as municipal waste.

PUBLIC EXPOSURE WORKSHOP

Dr. A. Gilman - Facilitator
Dr. M. Boddington - Rapporteur

This workshop dealt with both the exposure of people to dioxin sources and related communications issues. ~~the exposure of dioxins people and communications~~.

Science

In this area we examined two basic issues; the route of exposure and the degree or seriousness of exposure. These issues contained a number of subcomponents contributing toward the whole.

It was quickly realized that there was a serious controversy over which route, air or food, contributed most to exposure. Participants concluded that a significant amount of new data would be required to resolve this issue. Indeed, there are no guarantees that the issue could be resolved.

The seriousness of these risks was another hotly debated area of concern. Two subissues were the development of new toxicological data and its interpretation. We concluded that even if new toxicological studies were commenced immediately, their effect on the knowledge base would not be realized for a minimum of five years. Quite clearly, interpretations must be based on current knowledge and both hazards and risks estimated appropriately. The justification for reduced exposure should be founded in prudence, not based only on an imminent threat to public health.

It was not clear from the scientific data what the global trends in environmental levels and human exposure really were. Apart from the valuable time series on Lake Ontario herring gull eggs, most data are sporadic and do not lend themselves to time trend analysis. Considering the enormous capital expenditures being predicted for abatement technology, the need to monitor dioxin levels on a continuing basis was considered essential as an affirmation that levels, and hence exposure, were not increasing and as a confirmation that controls were reducing environmental levels.

The workshop participants outlined a targeted research plan (Figure 1). CCREM should establish a Task Force to further develop the proposals and examine potential as well as realistic costs and timeframes.

FIGURE 1

TARGETED RESEARCH PLAN

1. Resolution of exposure pathways:
    - data to support multi-media analysis in air, water, soil, consumer products.
2. Resolution of source:
    - which source should be controlled to reduce exposure.
3. Identification of critical groups:
    - sports fishers,
    - breast feeders.
4. Monitoring trends in the environment:
    - evaluate progress,
    - show reductions,
    - improve credibility.

The participants also addressed the implications of a failure to endorse these proposals. The real risk of an increase in exposure and a concomitant increase in effects was regarded with considerable seriousness. There was particular emphasis on the implications for critical subgroups such as breastfeeding infants. Given the high cost of control programs, it was agreed that such initiatives should be targetted at high priority sources. The success of control programs will be measurable only over the next two to three decades, not the next two or three years.

Communications

The need to reach the public and respond to its concerns led to discussions on communication. This issue included two broad questions -- what to communicate and to whom.

In essence, the "what to communicate" was the truth. Over the years it has become increasingly difficult for the public to differentiate true from false in the scientific controversy over dioxins.

Participants agreed on the need for fact sheets that disseminated the best available information to the general public. However, more important is the need for scientists and bureaucrats to communicate their knowledge more effectively. Public confusion is as much a result of bureaucratic ineptitude and scientific grandstanding as of media misrepresentation.

The development of a clear unified communications plan was seen as the best way to resolve the communications issue. An outline of this plan is Figure 2, which should be fished out by the Task Force.

FIGURE 2

UNIFIED COMMUNICATIONS PLAN

1. Information sheets for general public.
2. Information sheets for technical experts
3. National Task Force
    - advice on issues,
    - evaluate new data,
    - identify emerging issues,
    - prepare background papers,
    - harmonize responses,
    - report progress,
    - act a formal contact point.

The workshop participants believed that both reduced exposure and good communications dipicted on a solid remedial action plan (Figure 3). Some of the needs of such a plan were outlined but need to be developed much further.

FIGURE 3

REMEDIAL ACTION PLAN

- need strong non-inflammatory statement on human exposure to support need for controls
- need to reduce exposure to humans
    - know enough to reduce sources
    - not sure how much reduction
    - not sure specific effects
- need to include related compounds with dioxins
- need interim policy to control major sources with Best Practicable Technology.
- need strict product control
    - use and content

It became clear during the discussions that there were "informed" and "uninformed" segments of the workshop. The reactions of each were different and would lead to different responses to public inquiries. These different knowledge bases highlight the need for governmental and scientific networks to pass information to regional centres. The effectiveness of the scientific network would depend upon the quality of the available data and the areas of expertise of the individual members.

SUMMARY OF PUBLIC EXPOSURE WORKSHOP OBSERVATIONS

1. A targetted research plan to resolve the issues of:
    - prime sources,
    - exposure pathways,
    - critical groups,
    - environmental trends.
2. Communication plan:
    - coordination of the issuing of honest, complete information.
    - production of fact sheets for the public and technical inforation sheets for scientists.
    - establishment of technical resource information networks for science and for policy and communication issues.
3. A remedial action plan should include:
    - a public statement on human exposure,
    - an interim policy on control by Best Practicable Technology.

SECTION 3

SUMMARY OF WORKSHOP CONCLUSIONS

SUMMARY OF WORKSHOP CONCLUSIONS

Beverley Thorpe

The purpose of our workshop was:

- to identify priorities for action in scientific, economic and regulatory areas;
- to identify some communication themes; and
- to address the topic of regional highlights and differences.

I think we came up with suggestions and comments addressing all these topics.

Science, Economics and Regulations

One of the priorities for action identified in the public exposure group is that there is a current exposure issue. However, there are data gaps and we should be targeting research to identify what information is most needed for the Canadian situation and to deal with regional variations in sources and exposure. The regional differences in analytical capabilities and, further, our inability to analyze for some dioxins and dibenzofurans in various media and at the levels of detection that we require -- affect our ability to adequately determine exposure. We have a lot of gaps in ambient air information, we have quite good data on water, but there is very little data on food. Some data is available on certain consumer and chemical products, such as pesticides. There is variation in the data available on sources leading to exposure.

The workshops have identified control priorities developed on the basis of available information and the current possibilities of exposure due to combustion, chemical and historical sources. However, there are some technical and scientific limitations on our ability to control those areas and also to determine whether or not we indeed need to control them.

Under economic issues, we've heard that dioxin analysis is very expensive. When we have scarce resources, as we do always in dealing with environmental and health issues, how do we determine where dioxin priorities fit with other chemicals?

There is a quite useful theme coming through that because of the high cost, we should use what data or knowledge others have developed. CCREM should establish both formal and informal mechanisms to cooperate and share information. At least two groups suggested that some type of a formal information-sharing network be established under CCREM to exchange technical ideas and develop plans, e.g., for regional laboratory facilities. Such sharing would go a long way to addressing what is otherwise a very, very expensive problem.

In order to assess the possible economic benefits of things like control technology, we must determine how serious the problem is and, indeed, whether we should be spending money on this as opposed to something else.

The third sub-category of priorities for action was in the area of regulation. It is suggested that regulatory needs is renewed using the life cycle approach. CCREM has spent considerable time in adopting the life cycle approach and the dioxin action plan follows the life cycle approach. There are regulatory devices already in place for some of the stages. There is regulation in the area of pesticides. In the transport area there are limited regulations for dioxins and dibenzofurans under federal Transport of Dangerous Goods Act (TDGA). Under the stage of the life cycle there is work underway on codes of good practice, maximum allowable contaminant levels of dioxins are set for pesticides, and there are restrictions on hexachlorophene use, but there may be other needs as well.

In the disposal stage there is a need for national standards and guidelines for ambient environmental exposures based on the multi-media approach, and for discharge and emission standards as support to the control technology development for sources such as combustion of waste and disposal of hazardous waste.

Communication

There have been a number of excellent points made regarding communication needs. The "good news" story is one communication opportunity that's often missed. We tend to react to bad news. Other aeas opportunities to be more proactive on the "good news" are:

- Canada's position as a world leader in analytical work, such as the NITEP project, and in the development of monitoring techniques for a number of environmental meadi;
- we have been proactive in regulatory development, e.g., in pesticides;
- development of ambient air guidelines in Ontario and drinking water objectives;
- in the use of the multi-media approach; and
- in the development of toxic equivalency factors.

Another "good news" area is the environmental trend analysis showing dropping levels of 2,3,7,8-TCDD in Lake Ontario over the past 15 years. This also gives us a good data base to monitor future changes.

The workshops have made a number of conclusions on communications. One is that the dioxin issue should not be separated from other issues; it should be dealt with in the context of the broader issues like municipal solid waste incineration. Another is we should be more proactive in publicly advertising the availability of information. There was an excellent suggestion for a "state-of-the-environment" report on dioxins, to help put the information in perspective. A very important point was made about ensuring uniform and consistent information. Much time is required to correct misinformation that's already out in the public domain. Often credibility is lost when you try to change the public's perception of an issue.

The sharing and giving advance notice of data and information release between CCREM members would certainly be a very cooperative effort; it would help to reduce problems in terms of uniform and consistent information.

There was a suggestion that we need help as scientists and technical people in communicating these difficult issues to the public. The point was also made that we should be communicating with the public about what kind of remedial action plans we're going to be proposing.

Regional Issues

The regional highlights included the recognition that there are great variations in technical and analytical capability which can lead us to a number of problems. One disparity in exposure data, because without analytical capabilities in one area, you can't collect any ambient monitoring data, so you don't know what the current exposures are. Since the data on wildlife indicates that there could be variations in exposure, this would affect the development of national standards and the allocation of the allowable dose.

The major conclusion of this session was to form a permanent Dioxin Working Group reporting to CCREM to develop and coordinate future actions. The Standards Group to address potential problems of regional variations in exposure suggest that the national standards be based on average exposure but allow for the setting of more stringent standards on a regional basis to take into account critical sub-populations or local exposures. What may be a priority for action in Ontario may not be a priority for action in B.C. However, it's important to note that while there was a great variation in source types and exposures, there also are a number of similarities.

Summary

The networking of technical and policy staff is extremely important. We brought together people here who normally would never have an opportunity to talk to one another. A number of the participants have commented that this type of approach could be applied to other CCREM issues that would benefit from broad-based thinking and consensus.

By bringing you all together, we've achieved a number of obejctives of the Toxic Substances Advisory Committee and the Deputy Ministers and Ministers of CCREM: they will receive the coordinated consideration of what we think the issues are, the priorities and our suggestions so that they have a broad base of advice.

And, finally, there's the sharing of technical knowledge between policy and specialist staff. It was particularly important to have senior executives and policy staff along with scientific staff at this meeting to hear a lot about the issue. It makes discussing the issue a lot easier because we now share some common knowledge and understanding.

APPENDIX I

EXTENDED ABSTRACTS OF PAPERS SUBMITTED

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS

DIOXIN WORKSHOP
MAY 7 AND 8, 1987
CHATEAU FRONTENAC, QUEBEC CITY

SESSION 1. DIOXINS - AN OVERVIEW

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Dioxins have become, and remain, the issue that they are for three reasons; their potency, their ubiquity and their public association with broad environmental issues. The purpose of this overview will be to highlight some of the key scientific data and some of the key international incidents that have kept dioxins as a headline for 20 years. The attempt will also be made to delineate international from Canadian circumstances.

Dioxin is a complex organic molecule that can contain different amounts of chlorine. These different numbers of chlorine and their arrangement result in 75 different dioxins, the most well known and most toxic being tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). The dioxins differ from the dibenzofurans by the presence of an extra oxygen. The PCBs are also structurally very similar to dioxins and dibenzofurans.

The history of dioxins has no real starting point. In one instance, it can be traced back to chick oedema disease which caused deaths of U.S. chicken flocks in the late 1950s. The deaths were a result of contamination of chicken feed but the identification of hexachlorodibenzo-p-dioxin as the contaminant responsible for chick oedema disease did not occur until the late 1960s. By 1969, there was a concern over the contamination of the phenoxy herbicide 2,4,5-T with 2,3,7,8-TCDD. Links were also made to 2,4,5-trichlorophenol (TCP) and its use as an intermediate for 2,4,5-T and hexachlorophene production. In the late 1940s, workers involved in industrial accidents in the production of TCP developed a skin condition called chloracne (a boil-line acne). Chloracne was also reported in some PCB workers. By the early 1970s, the similarity of action of 2,3,7,8-TCDD, other dioxins, PCBs and their contaminants - the dibenzofurans - was well established.

The phenoxy herbicides 2,4-D and 2,4,5-T have been used since the 1940s because of their effectiveness in simulating plant hormones, leading to accelerated growth and eventual death of broad-leafed plants. In the 1960s, the phenoxys, in specific mixtures such as Agent Orange, were used as defoliants in Vietnam. The use of defoliants was cause for protest during this period, and many of the public perceptions today are a reflection of moral judgements made in that era. The fact that a highly toxic contaminant, 2,3,7,8-TCDD, was present in significant amounts (parts per million) combined with the fact that the phenoxy herbicides were used in the U.S. on rangelands, rice paddies and forests, prompted further public concern and debate. The debate over the use of phenoxy herbicides still continues.

In Canada, restrictions on the use of 2,3,7,8-TCDD content of 2,4,5-T, together with regulation of the dioxin content of 2,4-D, resulted in much cleaner products. Provincial restrictions further reduce the amount of 2,4,5-T used in Canada which was finally deregistered in 1985.

Environmental residues of 2,3,7,8-TCDD were for many years very difficult to detect. In the early 1970s, detection limits for toxic substances were usually in the parts per million (ppm) range. 2,3,7,8-TCDD was, however, rarely found at these levels and so there were few data that caused any concern. In the mid-1970s, there was a series of questionable results reporting 2,3,7,8-TCDD in the environment. These reports caused so much debate among scientists as to their validity, their meaning and the potential effects that they led to considerable confusion. More sophisticated analytical equipment was developed that brought detection limits in the parts per billion (ppb) range into common usage. Later, detection limits for 2,3,7,8-TCDD reached parts per trillion (ppt) and subsequently parts per quadrillion (ppq) in 1983. The quest for accurate identification of dioxins, particularly 2,3,7,8-TCDD, has done more to advance the field of analytical chemistry than research of any other chemical; however, in the late 1970s when validated dioxin results became available, the confusion and concern resulting from the earlier problems still existed, as indeed they do today.

Three specific incidents highlight the confusion and debate of the mid-1970s. The first was a citizens' survey of miscarriages in Oregon which implicated 2,4,5-T from forest spraying. Even though the survey was later discounted, the public concern was considerable. The use of 2,4,5-T was discontinued temporarily in the U.S. The press coverage had an impact on Canada because of our own use of 2,4,5-T in forests. Ontario, British Columbia, New Brunswick and Saskatchewan stopped the use of 2,4,5-T. The same debate resulted in Quebec stopping spraying for the 1983 season. The court judgement on spraying in Nova Scotia found no evidence to substantiate the alleged risks. 2,4,5-T was effectively banned from Canada as of January 1, 1986.

The second incident was a major industrial accident at Seveso, Italy involving TCP production. Considerable areas of the surrounding town and countryside were contaminated resulting in large losses of many animals. Some of the townspeople, notably children, developed chloracne and some neurological disorders. Although other such incidents had occurred in Europe and the U.S., the connection between TCP, 2,4,5-T, hexachlorophene and 2,3,7,8-TCDD has not been previously made clear to the general public even though it has been known in scientific circles for at least 10 years.

The third incident involved the Love Canal waste disposal site in Niagara Falls, N.Y. Subsequently another waste dump - Hyde Park - was identified in the same area. Much of the early concern was raised by the group of Love Canal residents concerned about their families' health. There was again an epidemiological study that was later discounted that led to considerable debate over the levels of contaminants. The residents were eventually moved but the debate continued. Canada's attention was directed towards the Niagara problem in the late 1970s and early 1980s by the ability to detect 2,3,7,8-TCDD at very low levels. Environment Canada's results for 2,3,7,8-TCDD in herring gull eggs focussed Canadians' attention on the 2,3,7,8-TCDD problem as being not just simply a waste dump problem but a problem of extensive widespread contamination of their own environment. Again, the problem was TCP through the inadequate disposal of still-bottoms, the wastes left after the manufacture of the product.

These three incidents were important in focussing the public's attention on 2,3,7,8-TCDD but did not represent the end of the problem in the U.S. In 1982, Times Beach, Missouri became renowned. This incident was also linked to TCP still-bottoms which had been mixed with PCBs and waste oils and used in the early 1970s as a spray to keep down dust. The beginnings of the problem have been known for many years as the "horse arena" incident because several horses died and children became sick after an arena was sprayed with this mixture in the early 1970s. Winter flooding in late 1982 that spread 2,3,7,8-TCDD contaminated soil over a residential area in

Times Beach, eventually led the U.S. government to relocate the population. Times Beach was only one of the areas that had been sprayed and the full extent of the problem is still being elucidated.

Although Dow Chemical became and often still is the centre of the dioxin issue, it maintains that contamination was not solely the result of chemicals but also their combustion. To enforce this argument, Dow published its "Trace Chemistries of Fire" hypothesis in 1976. In essence this theory concluded that, given organic carbon, chlorine, oxygen and a flame, traces of dioxins are formed. There is still considerable scientific controversy over several academic points but the data now available support the theory. The significance of combustion as a source of dioxins has yet to be fully determined.

The "Trace Chemistries of Fire" broadened public perception of the dioxin issue by highlighting the fact that there were indeed dioxins other than 2,3,7,8-TCDD. This was added to by Agriculture Canada's announcement of dioxins in 2,4-D in 1981. These dioxins were not 2,3,7,8-TCDD and are considered much less toxic than 2,3,7,8-TCDD. The historic relationship between 2,4-D and 2,4,5-T and Agent Orange further clouded the issue and, as a consequence, dioxins in 2,4-D continue to resurface as an issue, even though the dioxin content of 2,4-D is regulated by Agriculture Canada under the Pest Control Products Act.

At the same time as the 2,4-D announcement in 1981, Health and Welfare Canada reported the finding of dioxins in the livers of chickens housed on pentachlorophenol-contaminated wood-shavings. The dioxins in pentachlorophenol - a wood preservative - have been known since the late 1960s when, as already mentioned, they were identified as the causative agent of chick oedema disease.

More recently our ever-increasing ability to detect dioxins in the environment has extended our understanding of their ubiquity. Octa-dioxins have been detected in drinking water in Ontario. Some foods in Toronto have low levels of dioxins. Mothers' milk contains dioxins. Increasing significance is being given to combustion as a source, particularly municipal incinerators and many other types of burning as well. New sources are also being found, pulp and paper mills, steel mills, and diesel engines. Additionally dioxins substituted with bromine or mixtures of bromine and chlorine are being increasingly researched.

The dioxin issue is now something like twenty subissues - some, but not all, pertinent to Canada. World-wide many hundreds of millions of dollars have been spent on dioxin research, dioxin clean-up, dioxin controls and dioxin damages. In 1981 it was estimated that in the first decade (1970-1980) it had cost the international research community $100M, by 1985 it was considered that we had spent the first billion on the subject. Given the complexity and dimension of this subject, where should Canada be focussing its efforts - that is the subject of the workshop.

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS

DIOXIN WORKSHOP
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SESSION 2. ANALYSIS

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Two decades ago the group of chemicals, popularly, if not accurately, referred to as "dioxins" were thought to reside in the relative obscurity of chemical laboratories, making only an occasional appearance in unfortunate industrial accidents. Today the word "dioxins" competes successfully for space in newspaper headlines and evening newscasts. The public has come to associate the terms with a variety of images: aerial application of herbicides, leachate from abandoned sites, smoke emitted from incinerators and home fireplaces. The most predominant overriding image to the public is that of the extra-ordinary toxicity of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) demonstrated by animal tests. These toxicity considerations have dictated the requirement for the analytical chemist to quantitatively measure to concentrations ranging as low as parts per quadrillion. Development of an entirely new realm of analytical capability has been required to achieve reliable quantitative determinations. A large variety of sample types requires data for trend analysis, environmental impact, to assess human or animal exposure or data for risk/benefit analysis for decision-making. The analytical chemist has been required to support these needs and thereby is faced with the challenges of:

(i) the difficulty of achieving reproducible low-level data in the presence of much higher levels of similar complex organics for a wide range of sample types;

(ii) the difficulty of obtaining large numbers of data points at ultra-trace levels in a short time frame;

(iii) the difficulty in obtaining comparisons of data between the large number of agencies currently involved in dioxin analysis.

The scope and limitations of the analysis of chlorinated dioxins and dibenzofurans (CDD/CDF) will be discussed. Primary focus will be placed on:

(i) the problem involved in sampling;

(ii) the complexity of analysis of environmental and biological samples;

(iii) the cost of analytical equipment and support staff.

The analytical data provides the basis for assessing the exposure to target species including humans and to the environment in general. Understanding the technical complexity and limitation of generating validated low-level dioxin and furan data is crucial when data is being interpreted. A sound grasp of the limitations inherent in providing low-level data will lead to better decision-making in environmental and regulatory areas.

CANADIAN COUNCIL OF RESOURCE AND ENVIRONMENT MINISTERS

DIOXIN WORKSHOP
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SESSION 3. LEVELS IN HUMANS, FOOD AND THE ENVIRONMENT

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INTRODUCTION

Interest in polychlorinated dibenzodioxins (PCDDs) as human and food contaminants began in the early 1960s, when it was discovered that they were the class of chemicals responsible for several episodes of toxic symptoms developed by workers in chemical plants manufacturing 2,4,5-trichlorophenol, as well as for "chick oedema disease", which killed millions of chickens in the U.S.A. in 1957. Because of the extremely high toxicity of TCDD, concentrations of interest are typically in the part-per-billion (ppb, 10^{-10}) or even part-per-trillion (ppt, 10^{-12}) range. Analytical chemistry was unable to achieve this order of sensitivity routinely until the late 1970s, therefore the data base on TCDD levels in humans, food and the environment is a recent one relative to the history of the problem.

Other PCDDs which contain chlorine atoms at the 2,3,7,8- positions still rank as toxic chemicals, although they are progressively less toxic than TCDD as more chlorines (maximum 8) are added to other positions in the molecule. Levels of polychlorinated dibenzofurans (PCDFs) in humans and the environment are also of interest because sources, chemical properties and toxicity of PCDFs are similar in some cases to that of PCDDs and PCDFs. Recent evidence suggests that the majority of TCDD-like toxicity in wildlife may arise from a few minor PCB congeners, but the data base is still very limited, and the discussion in this paper will be confined to PCDDs and PCDFs.

The capability to determine most of the possible 75 ~~73~~ PCDD and 135 PCDF congeners in environmental samples was only developed in the early 1980s, and is still limited. Nevertheless, Canada is one of the advanced countries in this respect, ranking behind the U.S.A., but on a similar level to Sweden, Germany, Italy and Japan, and well ahead of Great Britain and France in qualitative and quantitative analytical capability.

LEVELS IN HUMAN TISSUES AND MILK

PCDDs with four, five, six, seven and eight chlorines per molecule (tetra-, penta-, hexa-, hepta- and octa-CDDs) are ubiquitous in human adipose tissue in the general population of industrialized countries such as Canada, U.S.A., Sweden, Germany and Japan. Levels are typically 500-1,000 ppt for octa-CDD, 100-200 ppt for hepta-CDD and hexa-CDD, 10-20 ppt for penta-CDD and 1-10 ppt for tetra-CDD. The PCDDs identified all contain the toxic 2,3,7,8-chlorine substitution. In contrast, non-biological samples, such as flyash from municipal incinerators, contain many PCDDs in which these positions do not contain chlorine. PCDD levels in human milk are similar on a fat weight basis to that in adipose tissue, about 0.03 times levels in fat on a wet weight basis. Concentrations of the less chlorinated PCDDs, especially TCDD, are strongly correlated with age. This is a reflection on the long whole-body retention of these compounds. The half-life of TCDD is estimated to be about 6 years in humans. Present-day adipose tissue of the general population of China and 100 year old frozen Eskimo tissue have low or undetectable levels of PCDDs, indicating that modern use of specific chemicals and/or industrial activities in developed countries is the source of PCDDs found in humans. PCDFs, mostly 2,3,4,7,8-penta-CDF and 1,2,3,4,7,8,-hepta-CDF, are also present in human tissues, generally at levels less than 50 ppt on a fat basis.

LEVELS IN FOOD

Human tissues exhibit a pattern of PCDD and PCDF contamination which is similar to that in certain foods, but generally different from that observed in fish and wildlife, which is strong evidence for different origins. Studies of PCDDs and PCDFs in total diet have received scant attention. Results of a Canadian study which reported PCDDs and PCDFs in fresh fruit have not yet been confirmed. The Ontario Ministry of Environment and Ontario Ministry of Agriculture and Food will have completed a study on PCDDs in foods by May 1987. A recent Japanese study found low levels of non-toxic TCDD isomers in vegetables, rice/wheat, fish, beef, pork, chicken and egg. Pork contained octa-CDD, and both chicken meat and eggs contained a wide range of PCDDs (mostly non-toxic) at less than 10 ppt levels. The source of the tetra-CDDs is probably the herbicide CNP, which is heavily used in Japan. A Canadian study on PCDD and PCDF levels in pork and chicken found mostly hexa- to octa-CDDs and CDFs, which were thought to arise from pentachlorophenol treated wood used in barns and litter. Atmospheric (combustion) sources are not likely to be responsible for most of the higher chlorinated PCDDs and PCDFs found in the general population. The Japanese study quoted above calculated that 6% of total PCDD intake in humans could come from air, whereas chicken eggs alone accounted for 28%. Human foods, which potentially contain PCDDs from an airborne source via deposition to vegetation, such as beef and cow's milk, have very low or undetectable levels of PCDDs except when the cattle are grazing in the immediate vicinity of an incinerator. The source and vector of the low levels of TCDD in humans has not been determined. Several extremely low-level sources may be involved.

LEVELS IN THE ENVIRONMENT

A feature of the environmental PCDD/PCDF data base is that many analyses were performed in response to specific incidents where the source of contamination was well-known: industrial accidents, waste disposal and so on. However, like dietary studies, there have been few attempts to determine levels of general environmental contamination. The data that do exist indicate that organisms at the top of aquatic food chains have the highest levels, which is true for most other organochlorines, such as PCBs. In Canadian fish-eating birds and Arctic mammals remote from point sources, 2-40 ppt levels of TCDD and octa-CDD in fat and liver are typical, but no other PCDD or PCDF is usually detected. Great blue herons in several colonies in British Columbia have a unique pattern of PCDD contamination, hexa-CDD greater than penta-CDD greater than TCDD, which may be related to heavy use of chlorophenols in this area.

PCDD contamination in the Great Lakes has been studied more intensively than in any other large-scale environment in the world. The Great Lakes is a microcosm of global PCDD contamination because potential PCDD sources range from mainly atmospheric in Lake Superior to various urban/industrial sources in the lower lakes. Air particulates and sediments in the basin have a PCDD/PCDF pattern consistent with combustion sources, although more isomer-specific analysis is required for definitive interpretation. Using dated sediment cores, it appears that PCDDs and PCDFs escalated rapidly about the time manufacturing of chlorinated organic compounds increased in the 1930s and 1940s. Current levels (mostly hepta- and octa-CDDs and CDFs) in sediment are 500-2,000 ppt (dry weight). TCDD has not been detected in Great Lakes sediment or water except in Lake Ontario sediments. However, TCDD has been found at ppt-ppb levels in sediments of creeks, storm sewers and rivers draining into the Niagara River and Saginaw Bay, Lake Huron.

Except in areas where point-sources dominate, fish in the Great Lakes contain mainly 2,3,7,8-tetra-CDF and 2,3,4,7,8-penta-CDF at levels less than 50 ppt. Highly chlorinated and non-toxic PCDDs and PCDFs are not accumulated by fish. Recent TCDD levels in fish are generally below the detection limit (1-5 ppt) in all areas except Saginaw Bay, the Tittabawassee River (draining into Saginaw Bay), Lake Ontario and the Niagara River area. TCDD levels are less than 10 ppt in small fish (alewife, smelt) and less than 30 ppt in large fish (salmon, trout) in Lake Ontario. Snapping turtles in the upper St. Lawrence River accumulated 200-500 ppt levels of TCDD in fat, and lesser amounts of other PCDDs and PCDFs, presumably from a Lake Ontario source. Eels in the St. Lawrence River had 15-30 ppt TCDD, whereas those from the Richelieu River had undetectable levels.

The geographical and temporal trend of PCDDs in the Great Lakes has been defined best by analysis of herring gull eggs. In 1986, "background" levels of TCDD, penta-CDD, hexa-CDD and penta-CDF were 10-30 ppt each in Lake Superior, Michigan, Huron and Erie eggs. Levels of all PCDDs were 3-4 times background in Saginaw Bay eggs, and levels of TCDD were 2-3 times background in Lake Ontario eggs. Point sources are therefore indicated in the latter areas. The long-term trend in TCDD levels in archived gull eggs from Lake Ontario showed an exponential decline since 1971 with a half-life of about three years. Current levels are about 3% of those in 1971. There is no evidence of recent, sustained increases of PCDDs or PCDFs in gull eggs from any area of the Great Lakes.

One area of promise in future environmental monitoring is use of crustacean hepatopancreas as a biomonitor tissue. Analysis by the Canadian Wildlife Service of crab hepatopancreas from areas near Vancouver, British Columbia, showed complex patterns of PCDD and PCDF contamination, including several isomers without 2,3,7,8-chlorine substitution. Crabs accumulate PCDDs and PCDFs much more indiscriminately than fish, therefore sources of contamination are more likely to be identifiable.

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SESSION 4. DIOXIN SOURCES - COMBUSTION

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In 1978 the Dow Chemical Company hypothesized that PCDDs were created in essentially all combustion processes. This controversial hypothesis led to many subsequent studies on trace chemistry and have shown PCDD to be present in combustion products from wood burning, municipal solid waste incineration, industrial waste incineration, thermal processes for metals recovery, hospital and other biomedical incinerators, sewage sludge incineration, motor vehicle emissions and cigarette smoke. The relative contributions by these sources have been estimated for some locations but much still remains unknown. The following table taken from an Environment Canada publication lists some of these sources and their estimated potential contribution to the Canadian environment.

Additional work completed recently by the U.S. EPA under Tier 4 of their National Dioxin Study has extended this data base somewhat as shown in Table 2.

Depending on the nature of the fuel and the components of the mixtures being burned, the following three steps are necessary for PCDD and PCDF formation from chemically correlated precursors:

- introduction of chlorine atoms
- aromatization from non-aromatic precursors
- introduction of oxygen atoms

Table 1

Estimated PCDD Releases to the Environment from Combustion Sources

Source	Release gm/yr
Municipal Incineration	250 - 13700
Sewage Sludge Incineration	1400 - 3300
Coal Fired Utility Boilers	300
Woodfuel Combustion	800
Residential Oil Combustion	1
Residential Gas Combustion	900
Railway Ties	6000
Forest Fires	58700
Cigarette Smoke	2404
Motor Vehicle Emissions	200
Biomedical Incinerators	50 - 80

Table 2

Tier 4 PCDD Emissions

Source	PCDD ug/dscm	PCDD ug/hr
Secondary Copper Cupola Furnace	11,900	283,000
Salt-laden Wood-fired Boiler	195	4,190
Industrial Solid Waste Incinerator	625	1,810
Sewage Sludge Incinerator	53	780
Black Liquor Boiler	3	667
Wire Reclamation Incinerator (wire and transformer)	692	522
Black Liquor Boiler	1.2	230
Black Liquor Boiler	0.7	146
Wire Reclamation Incinerator (wire only)	168	113
Sewage Sludge Incinerator	20	40
Carbon Regeneration Furnace	4	32
Drum and Barrel Reclamation Incinerator	5	24
Sewage Sludge Incinerator	2	12

From experimental evidence so far it cannot be decided in which sequence the individual steps occur. A controversial topic is the source of chlorine in these mechanisms since both synthetic material such as PVC or simply naturally occurring inorganic chlorine could be sufficient as chlorine donors. Much work is necessary to elucidate the mechanism of PCDD/PCDF formation in order to avoid or at least suppress the formation of these compounds. Of great importance is also the question whether the PCDD/PCDF formation occurs mainly in the gas phase or on catalytic surfaces.

Returning to Table 1 and selecting the example of motor vehicle emissions, work done recently by Marklund in Sweden supports the importance of developing an understanding of formation and destruction mechanisms. In his experiment, Marklund examined emissions from two motor vehicles. The first was equipped with a catalytic converter using unleaded gasoline with no halogenated scavengers. The second vehicle had no catalytic converter and used leaded gasoline at 0.15 gm/l and a dichloroethane scavenger (0.1 gm/l). Both vehicles were in good condition and well tuned. No PCDD or PCDF was found in the emissions from the cars using unleaded fuel while the emission average from the cars running on leaded gasoline was found to be 30 - 54 pg/km of PCDD equivalents (Eadon method). It was assumed that the chlorinated scavenger was the precursor to the PCDD/PCDF formed. It was estimated that the total amount of PCDD/PCDF from cars in Sweden in this category would emit 10 to 100 gm/yr of TCDD equivalents (Eadon). Such findings may give further incentives to the conversion to lead-free fuels and further examination of other fuel additives. Rappe has suggested that this amount of PCDD/PCDF would equate to that emitted from 2 to 20 municipal solid waste incinerators.

In reference to municipal solid waste incineration, Environment Canada has made a significant contribution to the understanding of PCDD emissions from this source through the National Incinerator Testing and Evaluation Program (NITEP). Through NITEP, Environment Canada is seeking to establish the capabilities and limitations of combustion and emission control technologies in minimizing or eliminating the discharge of PCDD/PCDFs to the environment.

At the energy—from-waste facility located in Parkdale, Prince Edward Island, it was demonstrated that optimum combustion conditions for a two-stage modular incinerator can be defined which minimize the emission of PCDD/PCDF compounds (Figure 1)*.

It was further demonstrated that although combustion control was important, there were significant mechanisms taking place following the combustion process which contribute to the emission of PCDD (Figure 2). Although little if any PCDD was emitted from the combustion process, there was formation from precursors taking place as the gases cooled passing through the boiler. This emphasizes the need to control potential precursors in the combustion process and emphasizes the importance of a final emission control system.

Environment Canada, in cooperation with Flakt Canada, thoroughly assessed state-of-the-art emission control processes and was successful in demonstrating the potential for virtual elimination of PCDDs from the gas stream. The process studies included two configurations of lime scrubbing capabilities of this technology in removing PCDD. In all, 12 tests were conducted on this equipment and PCDD was detected (in quantities approaching the detection limit) only 4 times (Figure 3). Subsequent full-scale testing of this process in Sweden has confirmed these results.

* Figures appear at the end of this paper.

In the most recent NITEP work a state-of-the-art mass burning facility was studied in Quebec City. These tests, although not fully evaluated as yet, have confirmed the importance of good design and operation of the combustion process.

Figure 4 demonstrates the improvement achieved in emissions with a modern well-designed and operated system over previous old design systems.

Such work confirms that combustion processes can be designed and controlled in such a way as to minimize or eliminate the emission of PCDD to the environment.

Figure 1

Contaminant	Stack Concentration (at 12% CO$_2$) Dry			
	Normal	Long	High	Low
TSP (mg/Nm^3)	208	230	247	167
HCl (mg/Nm^3)	1 085*	1 070	1 165	950
PCDD (mg/Nm^3)	107	107	62	123
PCDF (ng/Nm^3)	143	156	95	98
PCB (ng/Nm^3)	801	58	0	126*
PAH (ng/Nm^3)	7 005	8 010	6 653	12 490*
Chlorophenol (ng/Nm^3)	4 346	3 773	2 706	6 591*
Chlorobenzene (ng/Nm^3)	4 321	3 161	3 968	4 884*
Cadmium (mg/Nm^3)	0.9	0.8	0.8	0.6
Lead (mg/Nm^3)	13.5	15.2	15.2	8.4
Chromium (mg/Nm^3)	0.04	0.03	0.1	0.03
Nickel (mg/Nm^3)	0.2	0.3	0.5	0.5
Mercury (mg/Nm^3)	0.7	0.5	0.9	0.5
Antimony (mg/Nm^3)	0.6	2.6	0.5	0.5

* only one non-zero value (two readings were below detection limit).

Figure 2

CONCENTRATIONS OF ORGANIC COMPOUNDS AT BOILER INLET IN COMPARISON TO STACK

	Concentration (ng/Nm^3 @ 12% CO_2)					
	Long Cycle		High Temperature		Low Temperature	
Compound	Boiler Inlet	Stack	Boiler Inlet	Stack	Boiler Inlet	Stack
PCDD	0	107	1	62	14	123
PCDF	0	156	0	95	10	98
PCB	11*	58	8*	0	61	126**
PAH	10 475	8 010	12 226	6 653	29 481	12 490**
Chlorophenol	486	3 773	479	2 706	2 941	6 591**
Chlorobenzene	6 595	3 161	4 895	3 968	8 906	4 884**

* only one non-zero value (two readings were below detection limit)
** based on average of 2 tests only

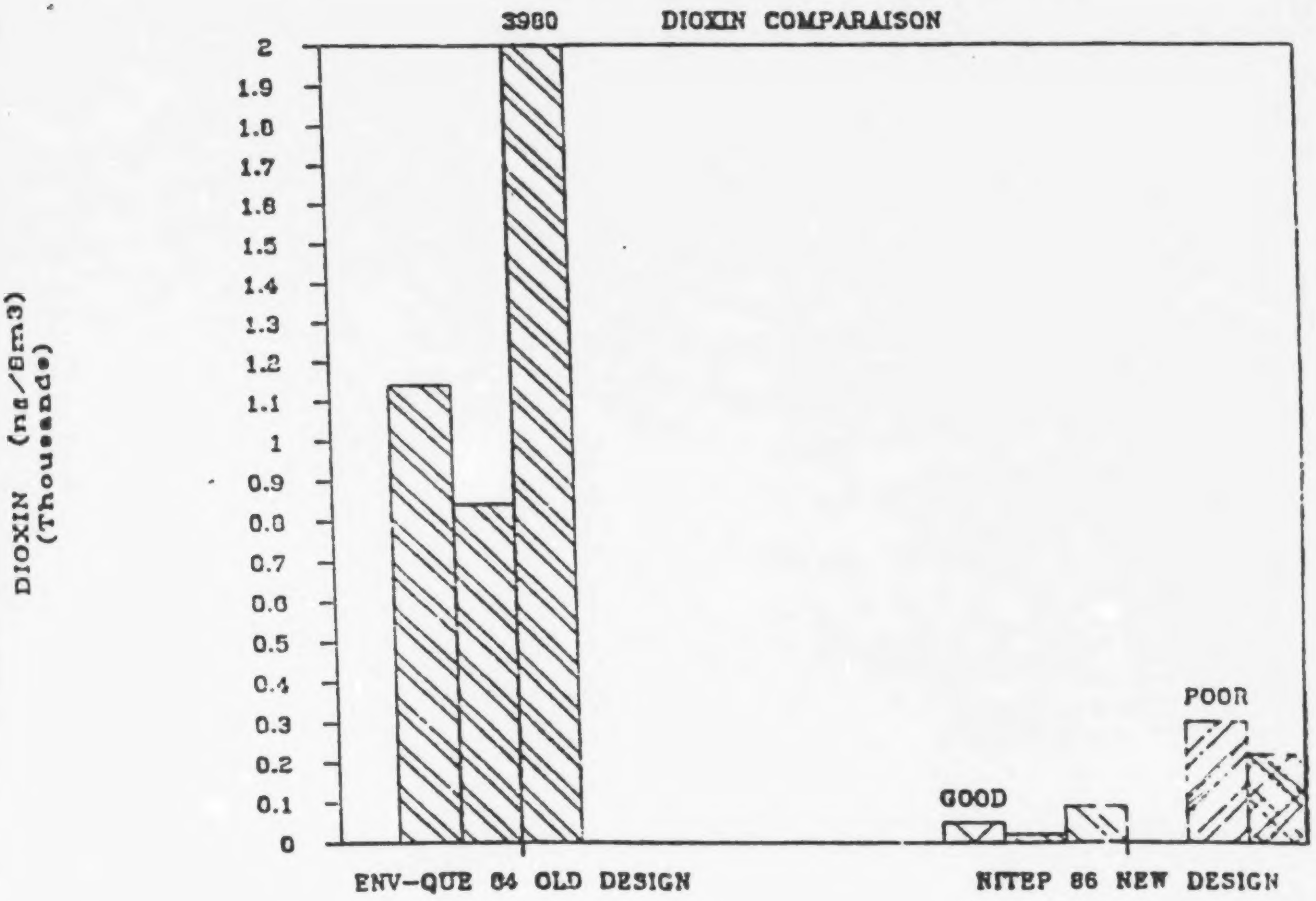
FIGURE 3

PCDD AND PCDF CONCENTRATIONS IN FLUE GAS AND EFFICIENCY OF REMOVAL

	Dry System								Wet-Dry System			
Operating Condition	110°C		125°C		140°C		200°C		140°C		140°C +Recycle	
	PCDD	/ PCDF	PCDD	/ PCDF	PCDD	/ PCDF	PCDD	/ PCDF	PCDF	/ PCDF	PCDD	/ PCDF
Inlet (ng/Nm^3)	580	300	1400	940	1300	1000	1030	560	1100	660	1300	850
Mid Point (ng/Nm^3)	310	270	570	440	540	630	1140	490	840	690	1270	1030
Outlet (ng/Nm^3)	0.2	2.3	ND	ND	ND	1.0	6.1	1.2	ND	ND	0.4	
Efficiency (%) - Inlet/Midpoint	47	11	60	54	57	37	(11)	13	24	-4	2	0.9 -21
Overall	99.9	99.9	99.9	99.9	99.9	99.9	99.4	99.8	99.9	99.9	99.9	99.9

Figure 4

MASS BURNING TECHNOLOGY



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DIOXIN WORKSHOP
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CHATEAU FRONTENAC, QUEBEC CITY

SESSION 5. DIOXIN SOURCES - PESTICIDES

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With the emergence of the toxicological significance of dioxins in the 1970s, a plan was developed by Agriculture Canada to investigate the extent of the problem as it related to pesticide technical active ingredients.

The activities of the department were first directed to establishing analytical capability and determining which pesticides could contain dioxins. This was followed by an orderly sampling and analysis program to establish specifically which pesticides contained which dioxins and at what levels. Using the authority of the Pest Control Products Act, regulatory standards and registration requirements limiting dioxins in specified products, were implemented. These were supported by extensive field monitoring programs to ensure compliance.

Complementary to the analytical program were formal re-evaluations conducted by the Pesticides Directorate on certain major use pesticides containing dioxins, e.g., 2,4-D, MCPA and pentachlorophenol.

New procedures to establish priorities on smaller use pesticides that may contain dioxins have been developed. These will be used to direct future efforts in this area.

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SESSION 6. INDUSTRIAL AND MUNICIPAL EFFLUENTS AND WASTES AS SOURCES OF PCDDs AND PCDFs

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Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) are inadvertent by-products associated with the commercial manufacture of chlorophenols. As well, combustion processes have been shown to produce most PCDD and PCDF congeners and isomers. The widespread use of chlorophenols in pesticides, pharmaceuticals and chemical formulations such as PCBs together with the extent of natural and anthropogenic combustion activities, have assured the ubiquitous distribution of PCDDs and PCDFs in the environment.

As research was initiated on the extent and significance of the environmental levels of PCDDs and PCDFs, controls were placed on the manufacture and use of various chlorophenols and restrictions have been set on PCDD and PCDF contamination in commercial products. Additional efforts are being made to establish the relative significance of the various sources of PCDDs and PCDFs to the environment.

The most persistent and toxic of the PCDD isomers, 2,3,7,8-TCDD, is relatively widespread in the environment, particularly at higher trophic levels, but significantly elevated levels are in most instances associated with the past production and waste disposal practices of 2,4,5-trichlorophenol (2,4,5-TCP) and its derivatives. This chemical, while not manufactured in Canada, was produced on the Niagara River for almost three decades. Wastes were dumped at a number of locations on the Niagara Frontier, including Love Canal, and some of these locations are now associated with the 2,3,7,8-TCDD transboundary contamination of the Niagara River and downstream Lake Ontario. Remedial efforts are being undertaken or planned and a major study has been initiated on Lake Ontario to determine the relationship of levels of TCDD in contaminated sediments and fish and to guide clean-up measures.

While 2,4,5-TCP has not been manufactured in Canada, other industrial processes have been associated with PCDD and PCDF contamination. The herbicide 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) is formulated from 2,4,5-TCP and has been shown to contain trace quantities of 2,3,7,8-TCDD. The herbicide has been produced at facilities in Canada but investigations to date have shown limited PCDD and PCDF contamination of soils and groundwater arising from past waste disposal activities at these facilities; off-site environmental contamination by 2,3,7,8-TCDD is not evident but investigations are continuing.

Tarry waste material found on the bed of the St. Clair River has been linked to the petro-chemical industry in Sarnia. A variety of chemical compounds are found in this material including PCDDs and PCDFs. The tetra- and octa- congeners of PCDD and PCDF predominated but neither 2,3,7,8-TCDD nor 2,3,7,8-TCDF was found.

Pentachlorophenol contains the higher chlorinated congeners of PCDD and PCDF and has been used extensively in the wood preservation industry. Contamination of effluents and adjacent soils and sediments has been demonstrated in Canada. Improvements in pentachlorophenol product quality together with better waste management at these facilities may have to be supplemented with site clean-ups and enhanced effluent treatment.

Investigations are being conducted in Canada and the U.S. at pulp and paper mills to determine the extent and source of PCDD and PCDF contamination associated with this industry. An eight mill study in Ontario found tetra, hepta and octa dioxins and tetra and octa furans in sludge samples but no 2,3,7,8-TCDD. This isomer had been previously found in the sludge of another mill.

PCDFs have been detected as trace contaminants in commercial PCB mixtures and the widespread use and losses of PCBs have no doubt contributed to environmental levels of PCDFs. Existing data, however, do not allow a determination of the relative significance of PCBs as a source.

With the ubiquitous presence of PCDDs and PCDFs in the environment, their presence in sewage should not be surprising. Trace quantities which have been reported in sewage appear to concentrate in the sewage sludge. The levels and congeners reported vary widely and are probably dependent on the nature of the domestic-industrial users of the systems. There is also the suggestion that PCDD contamination in sewage sludge predated major chlorophenol production and use, and could possibly be formed through the chlorination of naturally occuring phenolic compounds.

Levels of PCDD and PCDF contamination in the environment while widespread can be highly variable at the local level depending on the influences of a multitude of factors, some of which have been mentioned above.

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SESSION 7. EPIDEMIOLOGY/TOXICOLOGY

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Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are two chemically related families made up of 75 and 135 individual congeners respectively. The congeners are always mixed when detected in environmental media. Individual congeners have a wide ranging toxicity, hence assessing the health significance of exposure to mixtures of PCDD and PCDF congeners is extremely complicated.

The first phase of health risk assessment is the evaluation of the available toxicology data obtained from studies with laboratory animals or from epidemiological investigations. Several PCDDs and PCDFs, especially those chlorinated in the 2,3,7 and 8 positions, are extremely toxic, whether administration is for short (acute) or long (chronic) periods of time. Acute exposures of laboratory guinea pigs to less than 1 ug/kg b.w. of 2,3,7,8-tetrachlorodibenzo-p-dioxin leads to death within 3-4 weeks. Despite the wide range in lethal dose levels for laboratory species (1-5,000 ug/kg b.w.), 2,3,7,8-T_4CDD is clearly the most acutely toxic man-made substance tested.

In agreement with structure activity predictions, the next most toxic congeners are the 1,2,3,7,8-pentachlorodibenzo-p-dioxins and the hexachlorodibenzo-p-dioxins substituted with chlorines in the 2, 3, 7, 8 position. Octachlorodibenzo-p-dioxin is far less toxic (approximately 10,000 times) than 2,3,7,8-T_4CDD. The PCDF congeners are only marginally less toxic than their PCDD counterparts. Acute and chronic exposure of laboratory animals to the more toxic PCDDs and PCDFs leads to some or all of the following signs: weight loss (wasting syndrome); skin disorders (chloracne, loss of hair, pigmentation and thickening of skin); impaired immunity; liver disorders (impaired function, enlargement); alterations in blood dynamics; reproductive impairment (including defects in offspring); enzyme induction; development of benign and malignant tumors.

Long term exposures of rodents to low levels of 2,3,7,8-T_4CDD (0.001 to 0.3 ug/kg b.w/day) have led to an increase in several tumor types, especially carcinomas of the liver. A mixture of two hexachlorodibenzo-p-dioxin mixtures has also been shown to be carcinogenic for rodents. The mechanism of action that leads to tumor formation is not clear; however, these PCDDs do not appear to exert an effect directly on the genetic material of the cell, i.e., they do not act directly as mutagens.

Human beings have been exposed to relatively high levels of mixtures of PCDDs and PCDFs at some work sites (i.e. those associated with chlorophenol based pesticides manufacture and use, chlorophenol based wood preservation and protection, PCB manufacture and use, etc.) and as a result of intentional and accidental releases of contaminated materials. Effects such as reproductive failure, birth defects and increased cancer rates have been claimed in connection with exposures following the explosion of a pesticide reactor in Seveso, Italy, the use of Agent Orange in Vietnam and the use of 2,4,5-T in parts of the U.S. These reported effects remain unsubstantiated at the present time. Numerous confounding factors and, in some cases, small numbers of exposed subjects make meaningful scientific interpretation of these cases impossible.

More than 800 workers have been exposed to dioxins in industrial accidents. Chloracne and some neurological disorders (which disappear after a few years) have been observed in many of these exposed workers. Because of the long latent periods often associated with cancer, it is difficult to draw definite conclusions about the carcinogenicity of PCDDs and PCDFs for humans. The earliest well-documented case of human exposure resulted from an accident in 1949 in which 250 workers were exposed, and 122 cases of chloracne were reported; so far, 32 deaths versus 46.4 expected have occurred in this group with no apparent increase in deaths from malignant neoplasms. In other studies, an increase in soft tissue sarcomas (3 out of 105 workers, 2.86% versus 0.07% in the general population) has been reported. These studies neither prove nor disprove the carcinogenicity of PCDDs or PCDFs for man.

In man, the major health concern is over continuous or intermittent, low-level exposure and the potential for the more toxic PCDDs and PCDFs to adversely affect reproduction and to cause cancer. Consideration of all available data on the effects of exposure of humans and laboratory animal species, has led to the conclusion that human exposure of 2,3,7,8-T_4CDD should be kept as low as possible and should not exceed 2 to 10 picograms (pg) per kilogram of body weight per day.

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SESSION 8. REGULATORY REVIEW

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The primary aim for establishing environmental standards is to protect the health of Canadian citizens and their environment from the adverse effects of hazardous contaminants. This process involves estimating the potential for human health hazards and adverse effects on other organisms in the Canadian ecosystem due to the presence of, for example, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDFs) in the environment.

The problem of regulating chemical exposure is complex, since once released, chemicals partition into the major environmental compartments, i.e. air, water and land, according to their physical and chemical properties. An environmental standard should ideally take into account all environmental compartments, all routes of human exposure and all accumulation mechanisms affecting organisms in the Canadian ecosystem. This complex process is called the multi-media approach.

In evaluating the environmental health hazard of PCDDs and PCDFs, the objective is to determine the ambient concentration or maximum allowable daily rate of intake which over a lifetime of exposure will result in a non-toxic dose. This approach involves assessment of the human and environmental health risks posed by the presence of these chemicals.

Risk assessment and subsequent regulatory decisions should ideally be based on well-validated, reliable data. Since toxicity (and risk) is dose-related, the data should indicate the dose range or the range of environmental levels over which adverse responses occur.

Other supporting evidence, which may be related to the physical and chemical properties, chemical structure and biological activity of the chemical under review, will also be used in the risk assessment.

In order to evaluate the environmental health risk of PCDDs and PCDFs, it is necessary to know both the level of environmental exposure (exposure assessment) and the corresponding environmental health effects (toxicological assessment).

Most of our knowledge of the toxicology of PCDDs and PCDFs is based on acute and long-term animal studies and short-term genotoxicity studies done on tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Toxicological knowledge of the other PCDDs and PCDFs is quite fragmentary.

Exposure assessment is a complex, multi-disciplinary analysis whose purpose is to describe the contact between the contaminant substance with one or more individuals in the population.

Normal exposure is to mixtures of PCDDs and PCDFs which are not as toxic as if they consisted of only 2,3,7,8-TCDD. In order to make more realistic estimates of toxicity, the exposures are calculated on the basis of the toxic equivalent approach.

Data on the presence and concentration of the contaminant in body tissue are also useful to evaluate exposure assessments.

Environmental standards or guidelines developed by Canada and other jurisdictions will be reviewed.

APPENDIX II

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APPENDIX II

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